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ANALYSIS OF NONPOINT-SOURCE POLLUTANTS IN THE MISSOURI BASIN REGION

A. D. McElroy, et al

Midwest Research Institute

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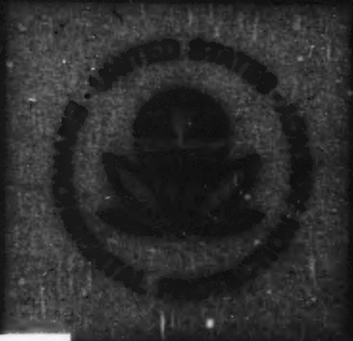

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Analysis of Nonpoint-Source Pollutants in the Missouri Basin Region

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A study was conducted of nonurban, nonpoint sources of pollution in the Missouri Basin utilizing a unique, computer-based data system. The Data Bank contains extensive information on land use, soil, climate, water quality, and other parameters in the Missouri Basin. The current study was concerned with the adequacy of the Data Bank relative to development of nonpoint pollution models.

Evaluation of information in the Data Bank yielded detailed land use and water quality profiles in the basin. The results show that the Data Bank is a useful base to depict the basinwide relations between various land uses and water quality. Regression equations of these relationships were developed for individual subbasins as well as for the entire basin. The regression equations, and the accompanying statistical analysis of significance, indicated that the water quality parameters NO3, BOD, and turbidity correlate well with land use on a basinwide basis. Other parameters, namely phosphorus, dissolved oxygen, and dissolved solids, did not correlate well with land use.

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March 1975

ANALYSIS OF NONPOINT-SOURCE POLLUTANTS IN THE MISSOURI BASIN REGION

By

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Contract No. 68-01-1863
Program Element No. 1BA030
ROAP 16AFN03

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ABSTRACT

A study was conducted of nonurban, nonpoint sources of pollution in the Missouri Basin utilizing a unique, computer-based data system. The Data Bank contains extensive information on land use, soil, climate, water quality, and other parameters in the Missouri Basin. The current study was concerned with the adequacy of the Data Bank relative to development of nonpoint pollution models.

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This report was submitted in fulfillment of Project Number 16AFN03, Contract Number 68-01-1863, by the Midwest Research Institute, under the sponsorship of the Environmental Protection Agency. Work was completed as of January 1975.

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SECTION I

INTRODUCTION

Water pollution from nonpoint sources is an area of justified concern to the Environmental Protection Agency and other water resources planning agencies in the nation. This concern is especially significant in the Missouri River Basin where the primary land use is agriculture. Methods to assess the degree of water quality degradation from nonpoint sources are currently less than adequate. Consequently, planning agencies are in urgent need of predictive tools to effectively implement the necessary water quality management strategies in various river basins.

Midwest Research Institute recognized this need several years ago, and initiated Phase I of the current program through the sponsorship of the Environmental Protection Agency (EPA Contract No. 68-01-0159). This Phase I study resulted in the development of a unique data bank for the Missouri River Basin comprising land use data, soil, climate, and other physiographic data, and water quality data in the basin. Land use data, soil data, and climatic and other physiographic data including crops, fertilizer use, and livestock data were based on each county (County Master File). These data were transformed to watersheds represented by selected water quality monitoring stations (Station Master File) which also contained water quality data. This data base was organized in a computer processible form. Because of the potential utility of the data base in characterizing the interrelationships between parameters of land use and water quality in the basin, the current Phase II(A) study was initiated under EPA Contract No. 68-01-1863. This study, in a relatively modest effort, was designed to further characterize data in terms of quality and quantity, and for potential utility in existing or new water quality models. Thus, the Phase II(A) program was set up to determine, the nature and merit of the data base for more comprehensive and detailed analysis.

This report presents and discusses the results of Phase II(A) study in the following sections:

II. Objectives and Scope of Study

III. Background Discussion on Phase I Study

IV. Approach to Phase II(A) Study

V. Results

VI. Conclusions and Recommendations

SECTION II

OBJECTIVES AND SCOPE OF PHASE II(A) STUDY

The following are the general and specific objectives and scope of Phase II(A) study.

GENERAL OBJECTIVE

The general objective of Phase II(A) was preliminary development and testing of appropriate water quality models for the Missouri River Basin, with the available data generated during Phase I. This broad objective was redefined early in Phase II(A), and a more limited objective was set: To thoroughly analyze the data and test its validity in terms of simple conceptual models, and thus to establish a firm basis for either the development (in anticipated continuing study) of comprehensive models, or for extension of the data base as required to improve its utility. Specific objectives, consistent with the general objective, are presented below.

SPECIFIC OBJECTIVES

The specific objectives of Phase II(A) were:

- To evaluate the adequacy of the data base of Phase I as inputs to models.
- To conceptualize and specify the type and form of these models.
- To make preliminary tests of the feasiblity of models with the available data.
- To appraise the tradeoffs between developing models which work with available data versus extended collection of additional data.

SCOPE

The data base contains extensive information on the agricultural practices which are the predominant sources of nonpoint pollution in the Missouri River Basin. In addition, essential information on climate, terrain, soil, water quality, and other pertinent factors is contained in the data base. The study involved analyses of these multiple factors for the entire Missouri River Basin as well as for selected subdivisions.

Thirteen subbasins were characterized according to land use and water quality, and the water quality/land use patterns along significant river basin segments were examined. The characterizations involved both computer assisted analysis and correlation of data, and collection and plotting of the various kinds of data which can be readily retrieved from the Data Bank.

The data base was thoroughly analyzed in terms of its comprehensiveness and quality of data for developing conceptual models, with emphasis on the impacts of land use practices on water quality in the basin.

SECTION III

BACKGROUND DISCUSSION OF PHASE I STUDY

In a preliminary effort to define and evaluate nonurban, nonpoint source pollutants in the Missouri River Basin, MRI compiled large quantities of data for the region during the Phase I study. These data were obtained from various data sources, and are discussed briefly in Appendix A.

Because the majority of land use and economic data are on a county base, a computerized data storage system was developed which relates county segments to watersheds. This system permits determination of correlations between land use data and water quality data, assessment of the contribution of agriculture and other nonurban pollutant sources to the degradation of streams and rivers in the Missouri River Basin, and will eventually be valuable for predicting the improvements in water quality that would result from specific nonurban control practices.

The data compiled in Phase I contain substantial amounts of pertinent information, a large portion of which is in computer-processible form. Data categories available include: water quality, hydrology, climatology, land use, topography, soil classification, livestock, pesticide use, fertilizer use, and other important economic data.

The organization of the data base is briefly discussed in Appendix B.

In order to interpret the significance of these data for the study area, the Phase II(A) study was initiated. The data interpretation involved a consideration of the nature of the basin characteristics--both intensive and extensive--in generating and transporting pollutants. The Missouri River Basin is predominantly agricultural in nature--agriculture occupies some 390,000 miles^2 (250 million acres or 100 million hectares) of farm land. This area represents about 85% of the total land area in the basin. Several kinds of pollutants are identified as significant in basin water quality. These include nutrients, pesticides, salts, sediments, organic residues, biodegradable wastes, and microbial pathogens.

The quantity of pollutants generated from nonpoint sources depends on the land use. For example, row crop production typically yields relatively large quantities of eroded sediments, while hay and forage crop production is less susceptible to water erosion. Similarly, feedlots in the vicinity of streams are expected to contribute heavily to stream pollution in terms of nitrates, biodegradable organics, and bacteria.

Sensible planning for control of pollutant emissions from agriculture and of water quality in surface and groundwater streams and reservoirs requires quantitative knowledge of pollutant loads as functions of several factors, and the inventory of supportable quantitative facts and data for assessing the fate of pollutants in the agricultural environment must be greatly strengthened. Prediction models for nonpoint pollution require a thorough knowledge of not only the land use characteristics and basic land characteristics, but also of pollutant generation and transport mechanisms. The validation of these models requires, in addition, data on water quality itself as well as on the dynamic behavior of the stream. In the past, discrete models have been developed on the various aspects of pollutant generation and transport, but these models have not been synthesized into a single useful form to comprehensively evaluate nonpoint pollution.

Thus, the functions generated in the current Phase II(A) study were dictated to a large extent by the available data and by model requirements for planning purposes. Consequently, the data base was analyzed in detail for quality and for the extent of its usefulness in models, and to determine if additional data should be acquired and incorporated in the data base.

SECTION IV
APPROACH FOR PHASE II(A) STUDY

RATIONALE

Nonurban, nonpoint source pollutants are among the most difficult to quantify of the many factors which influence the quality of the nation's water supply. They are generally introduced into streams, lakes and estuaries as a result of runoff from rural areas including cropland, grassland, range, forests and woodlands. The quantity and quality of rural runoff depend markedly on land use patterns and practices, and on the climatology and physiography which characterize a specific watershed. Such runoff can contain significant amounts of sediments, pesticides, organic materials, nutrients and dissolved solids. These pollutants can represent a significant portion of the total pollution load of a stream, and must therefore be carefully considered in the assessment of quality of water resources in a given region.

The systematic assessment of nonpoint source pollutants requires not only data regarding the type of pollutant but also data on the many factors which control the rate and manner by which the pollutants are introduced into the water system. These factors include local and basinwide topography, rainfall rates and frequencies, runoff characteristics, soil types and prevailing soil conservation practices, land use patterns, types of crops and their rotation, fertilizer and pesticide uses, livestock practices, and other features of agriculture, climate, and physiography.

As a result of the extensive Data Bank created by MRI during Phase I of the current study, most of the above factors can be comprehensively analyzed, for the first time, over the entire Missouri Basin Region. During the current Phase II(A) study, we selectively studied various parameters of land use, water quality, and other climatic and physiographic factors to determine the adequacy of the data base for establishing loading functional relationships due to various pollutant sources, and to establish on a preliminary basis the significant factors which can yield meaningful correlations and prediction models. In these analyses, which required extensive computer programming, the project staff provided value judgments and qualitative inputs which are possible only after a thorough persual of all relevant data available in published and unpublished form, and from personal contacts with experts in the field. Thus, we relied extensively on statistical procedures, but these analyses were tempered with insights gained during the project period.

The scope of the present Phase II(A) study was limited to establishing the value of the Data Bank and to developing and testing of certain relationships on a gross scale, in order to verify the validity of the data base and to develop an understanding of its strengths and limitations. It is expected that preliminary functional relationships will lead to the establishment of cause and effect relationships, which can be translated to planning and management tools on a local and regional level in the Missouri Basin, and with suitable modification adopted for national use. This background is an essential base for continuing study in a suggested Phase II(B) study aimed directly at development of functions which relate pollutant emissions to land use and land-use patterns, to natural causes and to other casual factors.

METHOD OF STUDY

The preliminary data analysis in Phase II(A) required reorganization of the data base. Separate computer programs were developed to retrieve selected variables in the data base, and to perform statistical evaluations. The specific methodology used in creating working files of data and in analyzing these data are discussed in detail in Appendix C.

The computer program listings are presented in Appendix D.

An analysis of quality of available data was performed by using standard statistical techniques. We have routinely used the Statistical Package for Social Sciences (SPSS), which contains subroutines for analysis of variance, correlation analysis, bivariate regression analysis, multiple stepwise linear regression, polynomial regression, factor analysis, nonparametric tests, and other procedures.

These computer data processing techniques were used primarily to screen pertinent variables to develop trends, correlations, and regression equations. The evolution of these equations/models was strongly influenced by the engineering judgment of the project staff in the selection of key parameters in the models.

TASKS

The research program for the Phase II(A) study included the following tasks in the preliminary analysis of data:

Task 1 - Evaluation of data for quality and quantity

Task 2 - Identification of the interrelationships among different types of variables

Task 3 - Preliminary selection and modification of relevant models

Task 4 - Development of computer programs

Task 5 - Appraisal of the models for accuracy and utility.

The protocol of analyses to evaluate source-stream and other relationships is shown in Figure 1.

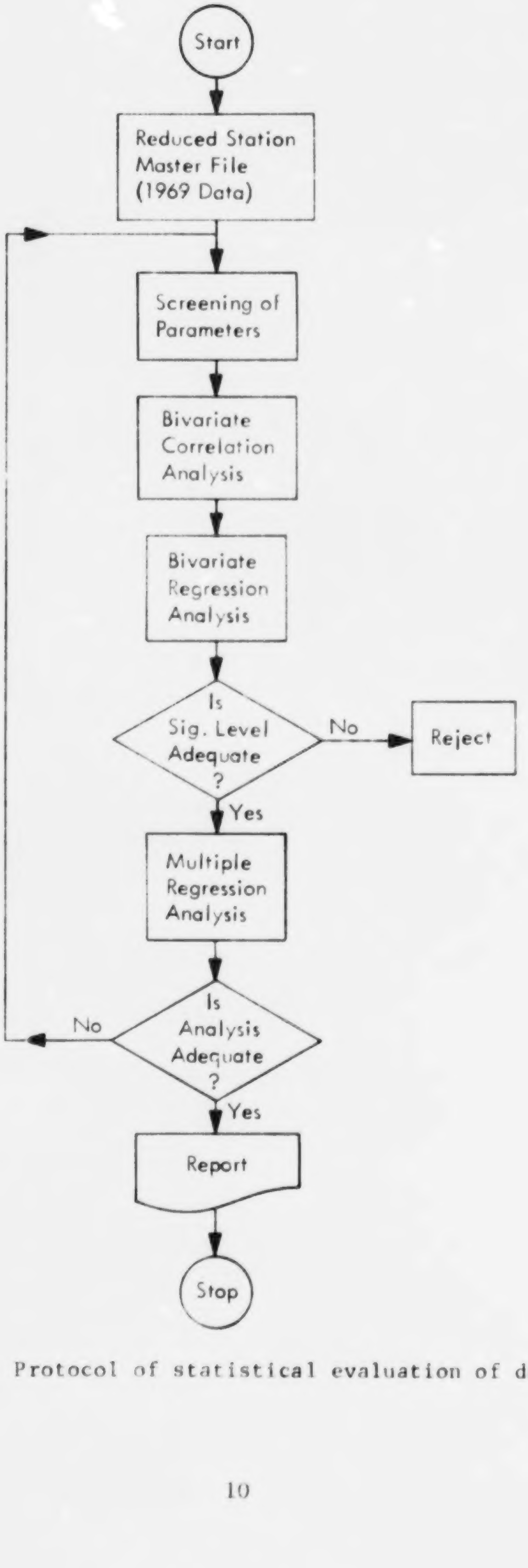
Task 1 - Data Evaluation for Quality and Quantity

An in-depth analysis was performed on both the quantity and quality of data available in our existing Data Bank. This analysis required both statistical techniques as well as engineering judgments regarding the operations and processes of land use activities, pollutant generation and transport, and water quality characteristics in the basin. This analysis was conducted to establish confidence levels for use of these data in subsequent modeling efforts.

The analysis included evaluation of the quality of land use and soil data by comparison of different data sources, and use of statistical techniques. The quality of hydrological and water quality data was also similarly analyzed.

Task 2 - Identification of Interactions Among Different Types of Variables

During this task, stream water quality parameters were analyzed to generally characterize water quality throughout the basin and develop significant relationships between water quality parameters. Similarly, basin characteristics (land use, topography, cropping patterns, etc.) were analyzed to develop correlations between individual basin characteristics, and additionally, to develop a basinwide characterization of the Missouri River Basin.



Start
Reduced Station Master File (1969 Data)
Screening of Parameters
Bivariate Correlation Analysis
Bivariate Regression Analysis
Is Sig. Level Adequate ?
No
Reject
Yes
Multiple Regression Analysis
Is Analysis Adequate ?
No
Yes
Report
Stop

Figure 1. Protocol of statistical evaluation of data

The land use and hydrologic data were adequate while data available on soil and water quality were extensive but contained significant voids. However, for developing basinwide characterizations of selected variables, the reliability of available data was shown to be good.

Stream Water Quality Characterization - Spatial water quality changes along the Missouri River and its tributaries were characterized at selected monitoring stations in terms of concentrations of pesticides, nutrients, BOD, dissolved oxygen (DO), suspended sediment, chloride, alkalinity, and pH.

Basinwide Characterization - The basin characteristics were evaluated in terms of land use, soil type, cropping pattern, topography, rainfall, irrigation, livestock, and chemical application (fertilizers and pesticides).

Several studies in the literature have related land use practices with pollution potential.[1,2] However, such definitive studies are lacking for the Missouri River Region or for a basin approaching this size. Use of the MRI Data Bank to produce relationships between pollution potential and land use patterns in the basin was a significant part of Phase II(A).

Correlations - Using standard statistical correlation and multiple regression techniques, the following relationships were evaluated:

- Water quality versus watershed characteristics.
- Pollutant loading rates versus watershed characteristics.

Task 3 - Preliminary Selection and Modification of Relevant Models

The preliminary development of models was based on the use of correlation techniques to identify the interrelationships among parameters of water quality and hydrology, and those of climatological, physical, and economic characteristics of each watershed. The next step was regression analysis to identify the significant parameters affecting the quantity and nature of pollutants.

---

[1] Bradford, R. R., "Nitrogen and Phosphorus Losses from Agronomy Plots in North Alabama," Env. Prot. Tech. Series. EPA, 660/2-74-005 (April 1974).

[2] Waldon, A. C., "Pesticide Movement from Cropland into Lake Erie," Env. Prot. Tech. Series, EPA, 660/2-74-032 (April 1974).

The preliminary models of Phase II(A) address the following needs:

1. To quantify the influence of existing nonurban, nonpoint sources on the pollution loads of the Missouri River and its tributaries, including the effects of natural variations in the source parameters.

2. To evaluate the technical aspects of changes in nonurban nonpoint source characteristics as a result of local, regional, or basinwide practices.

3. To evaluate the accuracy and adequacy of the available relevant data by using these data in the models and assessing the quality of the results.

The input to the systems models consists of the Phase I Data Bank and system constraints imposed by the program user. The constraints represent user interaction with the program, which enables a variety of technical alternatives to be evaluated.

Using presently available models, we initially chose those factors which may be expected to be related to runoff and its quality, broke them down into their simplest components, and chose factors having the least interdependence. This task required a knowledge of hydrologic and hydraulic principles, and knowledge of behavior of various pollutants, both in soil and in water. Statistical methods were applied to determine those factors that are most significant in causing pollution from nonpoint sources. The physical and economic factors are, in statistical terms, the independent variables that are to be associated with the concentration of pollutants in the river, which are the dependent variables.

A set of independent variables which are actually independent of each other would be preferable, but in our investigation this does not seem possible. There are very few variables which are truly independent, e.g., soil, groundcover and channel slopes may be affected by the amount of rainfall generally available. Thus, topographic and climatologic variables are not independent of each other; furthermore, fertilizer and pesticide uses are mutually related to agricultural practices.

Considering the interdependence of these variables, we used the following analytical procedures:

Correlation - We investigated the correlation of hydrologic and water quality parameters with physical and land use factors. Correlations between various water quality parameters and among physical and land use parameters were also studied.

We correlated, for example, BOD_5 and livestock; BOD_5 and crop acreage; turbidity and soil type; fertilizer use and nutrient (N and P) concentration; DO and livestock; crop acreage and pesticide use, stream flow and precipitation, etc. Correlation coefficients and variances were obtained.

For statistical analysis of data we utilized the Statistical Package for the Social Sciences (SPSS), in addition to the Scientific Subroutine Package (SSP) developed for use on IBM System/360. The former is useful in developing display tables of relationships between two or more variables, bivariate correlation analysis, partial correlation, and multiple regression analysis. For example, the subroutine CONDESCRIPTIVE will evaluate nine statistics, viz., mean, standard deviation, standard error, variance, kurtosis, skewness, range, minimum and maximum. PEARSON CORR subroutine computes linear, paired correlations, and can compute means and standard deviations of the variables listed. The subroutine REGRESSION will generate linear multiple correlations of two or more variables, either stepwise regression, or multiple linear regression. The statistics available for this subroutine are mean, standard deviation, and correlation coefficients.

Bivariate Regression - Initially, we developed two parameter regressions, i.e., bivariate regression analysis for pairs of parameters, to evaluate the effect of several parameters on water quality.

These analyses involved water quality parameters including DO (dissolved oxygen), turbidity, BOD (biochemical oxygen demand), P (phosphorus), NO_3 (nitrate), and DS (dissolved solids); and land use parameters including cattle, hogs, cattle and hogs, livestock (cattle, hogs, sheep, and chickens, converted into equivalent cattle), nitrogen and phosphate fertilizer applied, cropland and irrigated land.

The regressions were based on actual data, and on data transformed into natural logarithms. Data were fitted to a straight line form, $Y = A + BX$, where Y is a water quality parameter, X is a land use or physiographic parameter, and A and B are regression coefficients.

Multiple Regression Analysis - Multiple regression techniques were used to relate water quality parameters to physical, climatic and economic characteristics. The equation employed was based on the findings of correlations among variables and available correlations such as those developed by the U.S. Geological Survey. A stepwise multiple regression program was used to calculate the regression equation, the standard error of estimate, and the significance of each basin parameter. The calculations were repeated, omitting the least significant basin parameter in each calculation until only the most significant parameters remained.

Four water quality parameters were used for this study. These were:

a. Turbidity x flow

b. BOD

c. Nitrate

d. Turbidity

Calculations were repeated on data transformed into natural logarithms. Land use parameters selected for multiple regression analyses included cropland, irrigated land, cattle plus hogs, nitrogen and phosphate applied, rainfall, slope, and cover factor. A linear regression equation was used to fit the data. This equation is of the general form,

$$Y_i = C_i + \sum_{j=1}^{n} A_{i,j} * X_{i,j}$$

Task 4 - Development of Computer Programs

A listing of the computer programs developed during the study is shown in Appendix D. These include both the new data files created in a form that increases the utility of the data base at least cost, and the programs for statistical data analysis.

Task 5 - Appraisal of the Models for Accuracy and Utility

The data analysis resulted in several models that relate various water quality parameters to land use parameters. Their significance and reliability within the constraints of the quality of the available data was appraised.

SECTION V

RESULTS

Data analysis was aimed primarily at establishing that the data in our Data Bank are adequate to develop correlations and regressions among variables of selected water quality, land use, and physiographic parameters in the basin. In this section, we present the results of data analysis in the same sequence which enabled us to develop multiple regressions on selected variables. An evaluation and discussion of the results will be presented in Section VI.

Data from the Station Master File were used as the primary source in the data analysis. In this data file, land use, physiographic, and water quality data are listed for 233 watersheds, each being represented by a water quality monitoring station. These watersheds were assigned to 13 subbasins according to the classification of the U.S. Geological Survey Office of Water Data Coordination (OWDC). The entire Missouri Basin was covered by these subbasins: the northwestern portion of Missouri, the northern portion of Kansas, all of Nebraska, the western half of Iowa, the southwestern tip of Minnesota, most of North and South Dakota, northeastern Colorado, and most of Wyoming and Montana.

The latest land use data in the data file were reported for 1969, while water quality data were compiled for 3 years--1968, 1969, and 1970. After physical examination of the nature and extent of these data, it was decided to analyze 1 year's data (1969), which are available in terms of most parameters being analyzed. Consequently, the data analysis presented in this report is limited primarily to 1969 data unless otherwise stated.

BASINWIDE LAND USE CHARACTERIZATION

Basin land use data summarized for each subbasin and the entire basin are presented in Table 1. Mean values of various land use characteristics of the basin are presented in Table 2.

Table 1. SUMMARY OF LAND USE DATA BY SUBBASINS FOR 1969

Subbasin No.	Total land (miles^2)	Farm-land (miles^2)	Total cropland (miles^2)	Harvested cropland (miles^2)	Grazing land (miles^2)	Other cropland (miles^2)	Other farmland (miles^2)	No. of cattle
31	48,786	41,361	27,286	13,684	8,739	4,865	9,249	4,465,830
32	32,927	31,385	21,316	11,915	2,290	7,027	11,612	2,287,146
33	28,568	27,201	12,809	6,323	973	5,525	16,015	1,598,127
34	32,184	21,397	3,507	1,947	460	1,095	19,017	1,019,345
35	75,147	71,187	34,672	21,797	4,797	8,076	37,435	5,658,978
36	32,493	30,958	24,681	16,498	3,142	5,042	6,111	3,021,364
37	22,225	21,418	5,232	3,347	705	1,184	16,226	1,057,727
38	19,095	16,653	1,363	788	246	329	14,892	406,489
39	74,427	64,420	23,974	11,899	1,683	10,394	40,232	1,715,289
40	14,372	10,819	3,680	1,738	155	1,786	7,206	231,951
41	16,174	8,238	1,739	984	358	399	6,976	401,917
42	29,720	26,275	2,421	1,235	305	878	24,033	615,602
43	35,245	18,144	2,420	1,308	491	581	16,342	701,450
Total	461,363	389,456	165,100	93,463	24,344	47,181	225,346	23,181,215

Table 1. (Concluded)

Subbasin No.	No. of hogs	No. of chickens	N (tons)	PO_4 (tons)	Fertilizer ($N + PO_4$) (tors)	Herbicide (tons)	Insecticide (tons)
31	3,700,371	3,540,841	548,215	309,882	858,097	8,808	3,487
32	989,528	1,524,760	421,126	103,878	525,004	4,223	1,955
33	246,737	376,156	130,878	46,363	176,821	1,796	902
34	63,931	484,931	42,774	15,241	58,015	392	232
35	3,392,060	4,198,840	515,411	190,424	705,835	7,619	3,568
36	2,658,911	4,285,791	201,003	132,937	333,940	7,008	1,788
37	203,361	224,704	20,153	10,434	30,587	382	128
38	13,576	54,415	3,392	1,690	5,082	105	44
39	144,369	477,043	47,414	63,542	110,956	2,184	512
40	20,742	44,829	4,529	5,914	10,443	358	47
41	22,407	207,175	10,586	13,816	24,402	124	16
42	17,404	62,097	9,185	10,491	19,676	322	120
43	47,280	211,605	32,972	24,548	57,520	454	182
Total	11,518,677	15,693,187	1,987,218	929,160	2,916,378	33,775	12,981

Table 2. ANNUAL LAND USE LOADING IN MISSOURI BASIN, STATION MEAN VALUES

Subbasin No.	Cattle (No./miles^2)	Hogs (No./miles^2)	All livestock (as cattle) (No./miles^2)	Nitrogen (tons/miles^2)	Phosphate (tons/miles^2)	Cropland (miles^2/miles^2)	Irrigated land (miles^2/miles^2)	Annual rainfall (in.)
31	98.142	79.309	120.005	11.875	6.466	0.580	0.003	38.802
32	73.525	33.206	83.304	13.892	3.755	0.665	0.062	29.132
33	51.089	8.290	54.420	4.241	1.451	0.441	0.056	19.026
34	28.109	1.999	32.221	1.253	0.471	0.098	0.043	15.247
35	117.163	77.075	139.034	15.175	4.444	0.572	0.056	24.830
36	94.329	84.832	120.644	5.568	3.746	0.770	0.001	21.848
37	51.009	12.679	55.213	1.089	0.565	0.270	0.014	18.607
38	22.390	0.737	26.004	0.195	0.097	0.083	0.008	14.860
39	30.883	1.829	33.445	0.504	0.652	0.307	0.004	16.293
40	16.157	1.496	17.050	0.323	0.422	0.282	0.010	12.403
41	24.746	1.109	26.914	0.641	0.837	0.109	0.053	13.668
42	18.928	0.339	22.978	0.231	0.187	0.047	0.015	12.053
43	18.608	1.282	21.546	0.956	0.633	0.063	0.029	12.048
Mean	62.869	24.211	73.929	7.084	2.698	0.410	0.039	22.246
Median	54.1	8.7	57.8	3.5	1.3	0.44	0.02	21.4

These values are computed for each watershed by dividing the value of the land use parameter by the area of watershed represented by the water quality monitoring station. Thus, Station No. 1000016 in subbasin 31 has a total land area of 3,829 miles ^{2}, and includes 391,398 cattle. The computed cattle density for this station is 102.219 cattle/mile^2. An average of all such density values for subbasin No. 31 is 98.142 cattle/mile^2, as shown in Table 2. On the other hand, the average cattle density computed from Table 1 is 91.539 cattle/mile^2 which is significantly different from the station mean value of 98.142.

Figures 2 through 10 show the distribution of various land use characteristics in the Missouri Basin. Each subbasin in these figures is labeled by a number (31 through 43) along with the value of the measured or calculated parameter.

Figures 2 and 3 show the distribution of cattle and hogs, respectively, in the Missouri Basin. Subbasins 31, 32, 35, and 36 contain the largest numbers of cattle and hogs. Among these four, subbasin 31 has the largest number of cattle and hogs of all the subbasins.

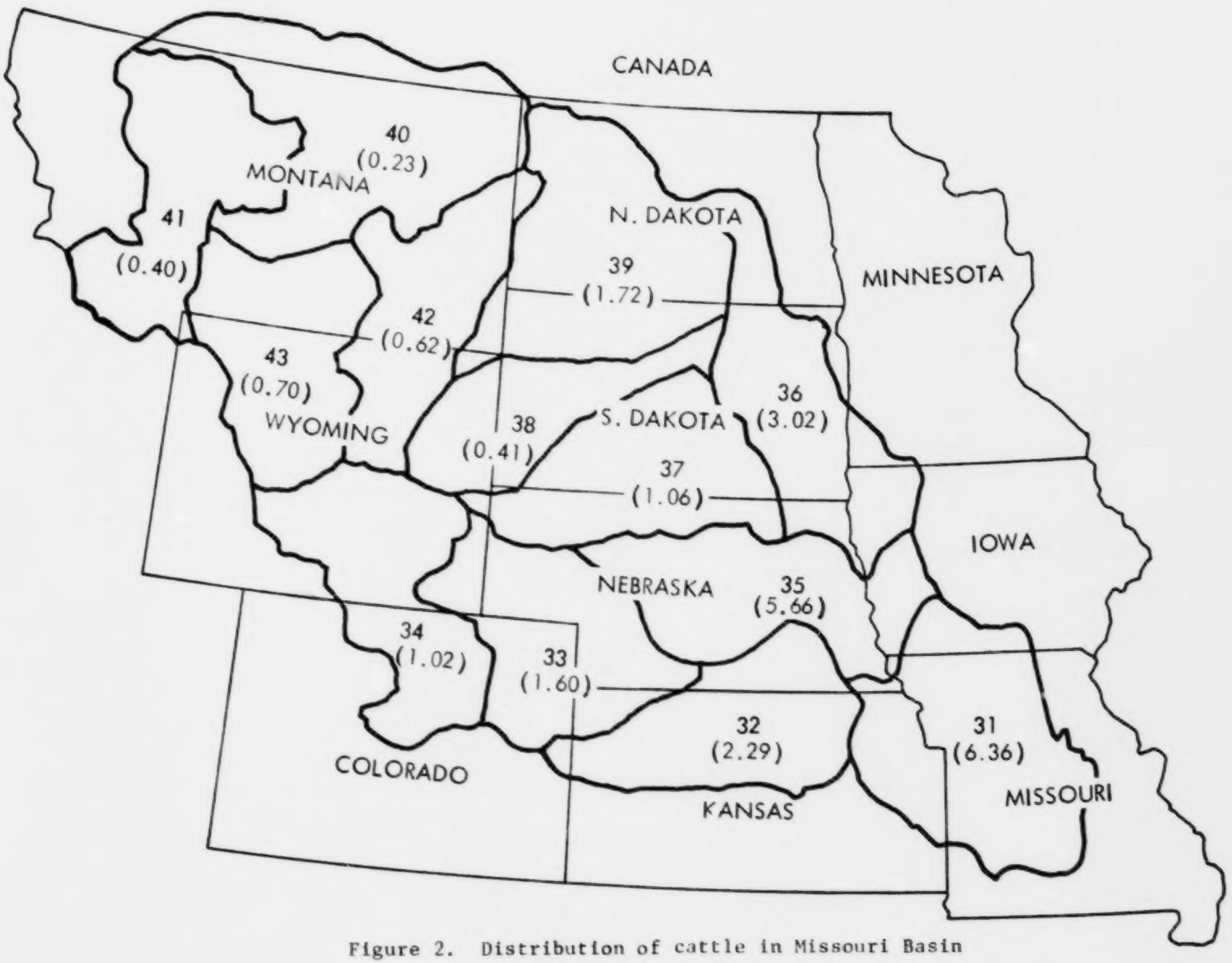
Figures 4 and 6 show the densities of cattle and hogs/mile^2 in each subbasin. In the case of cattle, subbasins 31, 32, 35, and 36 again record highest densities, with subbasin 35 showing the highest cattle density (117 cattle/mile^2) of all subbasins. In the case of hogs, subbasins 31, 35, and 36 show higher densities than the basin average, with subbasin 36 reporting the highest density (85 hogs/mile^2).

Figures 7, 8, and 9 show the distribution of fertilizer (nitrogen and phosphate), herbicide, and insecticide uses, respectively, in the basin. In each case, the four subbasins 31, 32, 35, and 36 show values above basin average. Subbasin 31 has the largest use of fertilizer and herbicide, while subbasin 35 has the largest insectide use.

Figure 10 shows the loading of fertilizer per unit area (tons/mile^2) Subbasins 31, 32, and 35 show values greater than the basin average, subbasin 35 showing the highest loading value of all subbasins.

BASINWIDE WATER QUALITY CHARACTERIZATION

Table 3 presents water quality characteristics in terms of selected parameters in each subbasin. These parameters include coliforms, dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, total filterable residue (TFR) or dissolved solids, nitrate (NO_3), and total phosphorus (P). Averages for the entire basin were also computed and presented in Table 3.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MONTANA
41
(0.40)
N. DAKOTA
39
(1.72)
MINNESOTA
42
(0.62)
43
(0.70)
WYOMING
38
(0.41)
S. DAKOTA
36
(3.02)
37
(1.06)
IOWA
NEBRASKA
35
(5.66)
34
(1.02)
33
(1.60)
32
(2.29)
31
(6.36)
COLORADO
KANSAS
MISSOURI

Figure 2. Distribution of cattle in Missouri Basin
(millions of cattle)

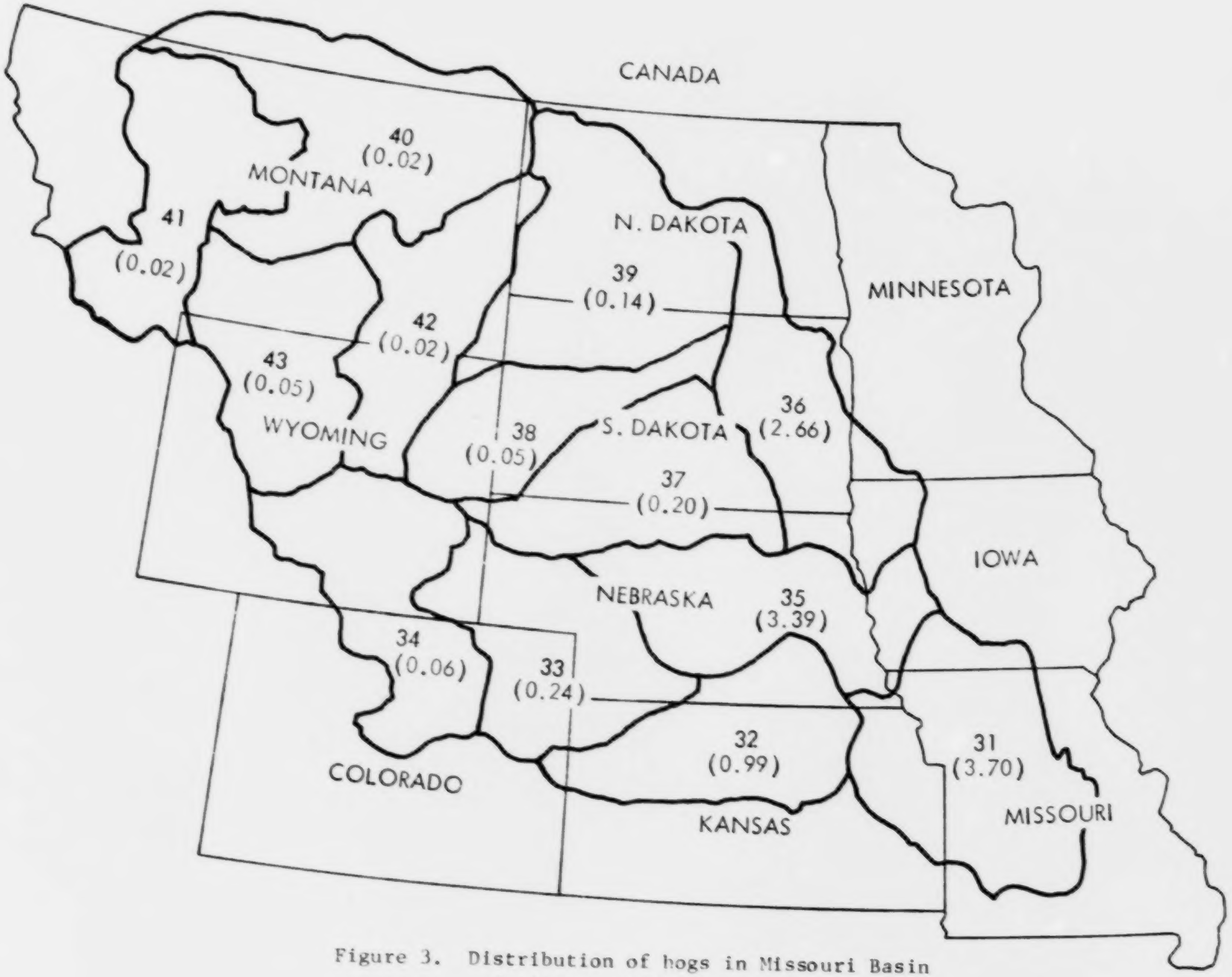
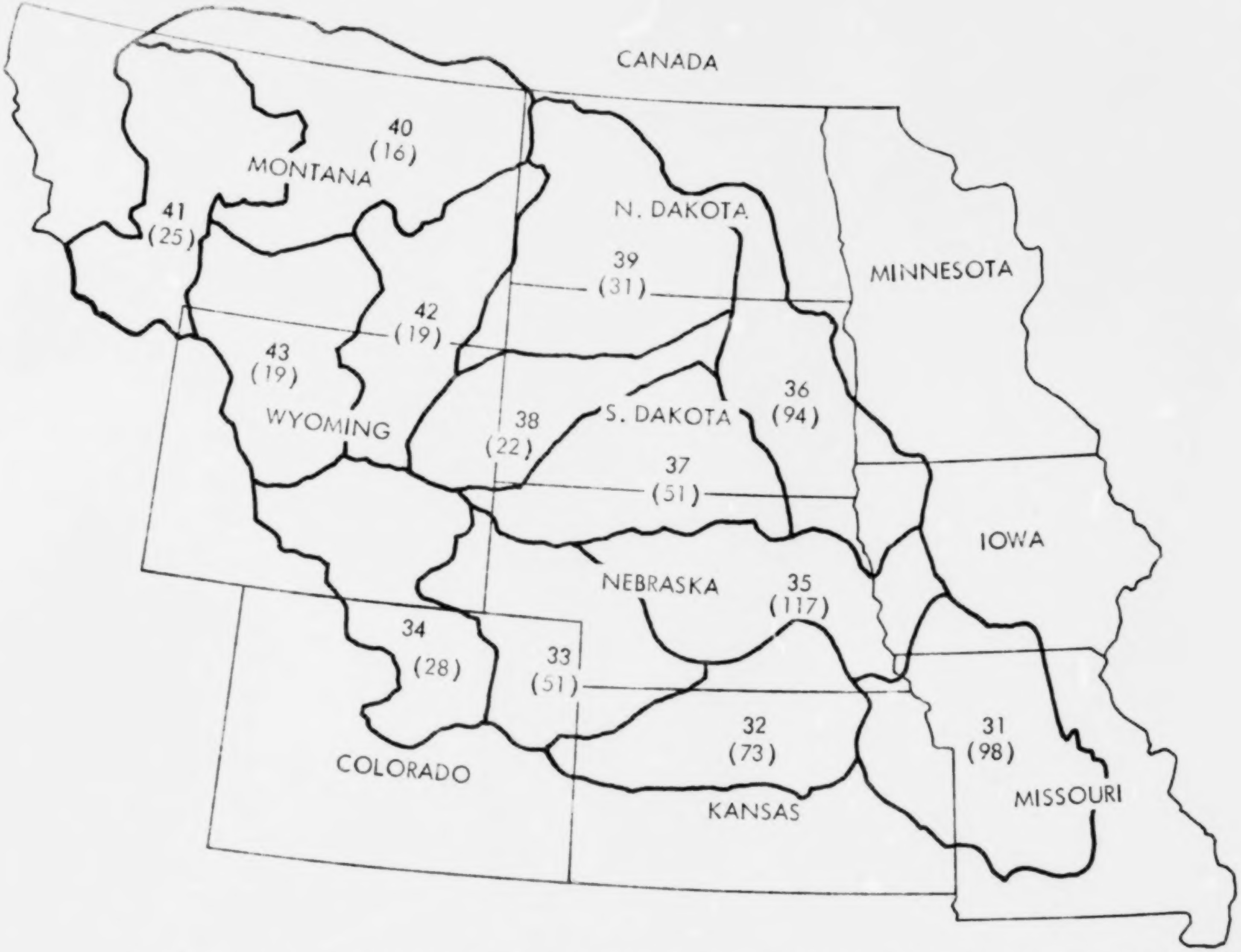

CANADA
MINNESOTA
IOWA
MISSOURI
N. DAKOTA
S. DAKOTA
NEBRASKA
KANSAS
COLORADO
WYOMING
MONTANA
31
(3.70)
32
(0.99)
33
(0.24)
34
(0.06)
35
(3.39)
36
(2.66)
37
(0.20)
38
(0.05)
39
(0.14)
40
(0.02)
41
(0.02)
42
(0.02)
43
(0.05)

Figure 3. Distribution of hogs in Missouri Basin (millions of hogs)



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(16)
MONTANA
41
(25)
N. DAKOTA
39
(31)
MINNESOTA
42
(19)
43
(19)
WYOMING
38
(22)
S. DAKOTA
36
(94)
37
(51)
IOWA
NEBRASKA
35
(117)
34
(28)
33
(51)
32
(73)
31
(98)
COLORADO
KANSAS
MISSOURI

Figure 4. Distribution of cattle per square mile in Missouri Basin, Station Mean Values (basin average = 63)

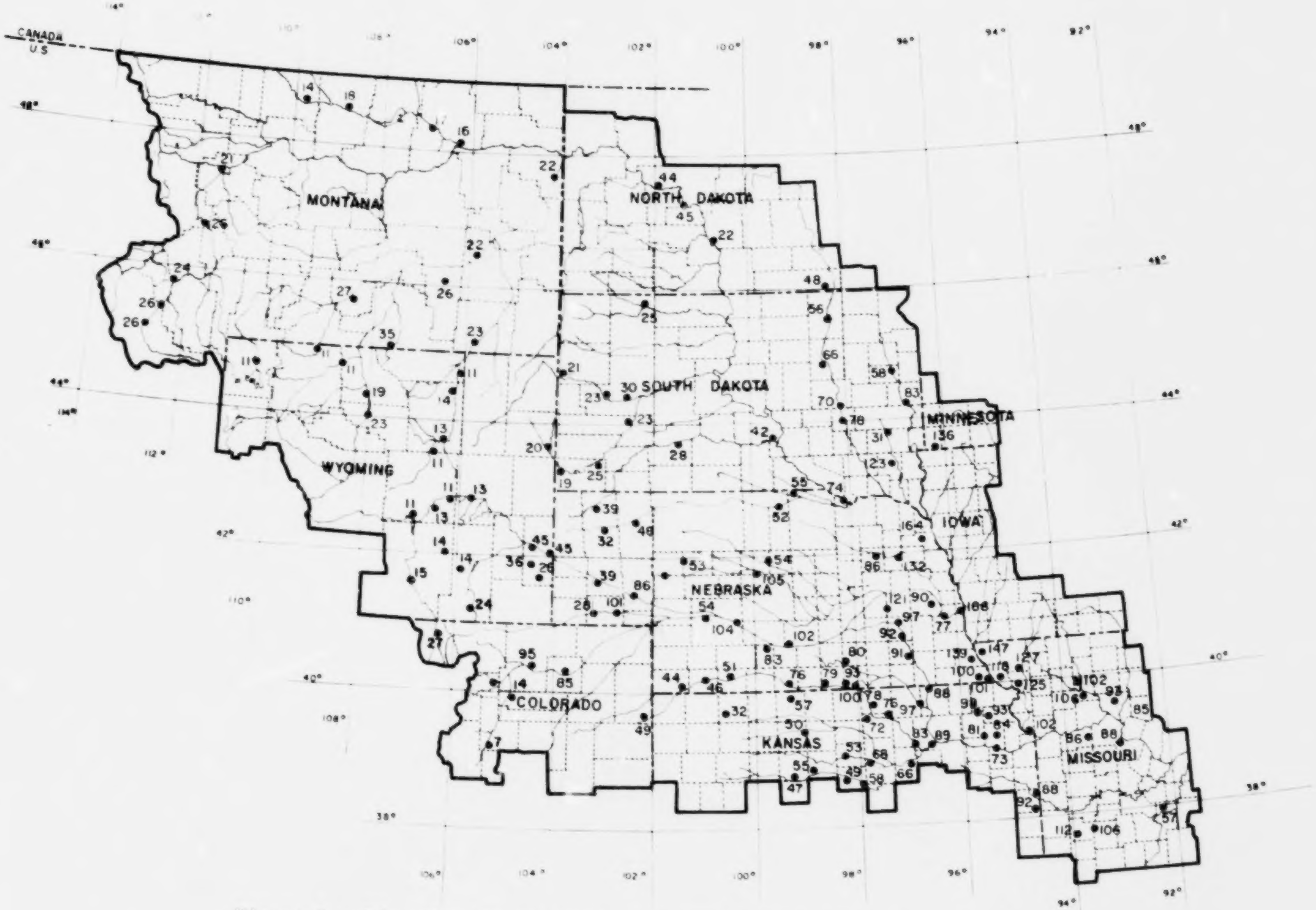
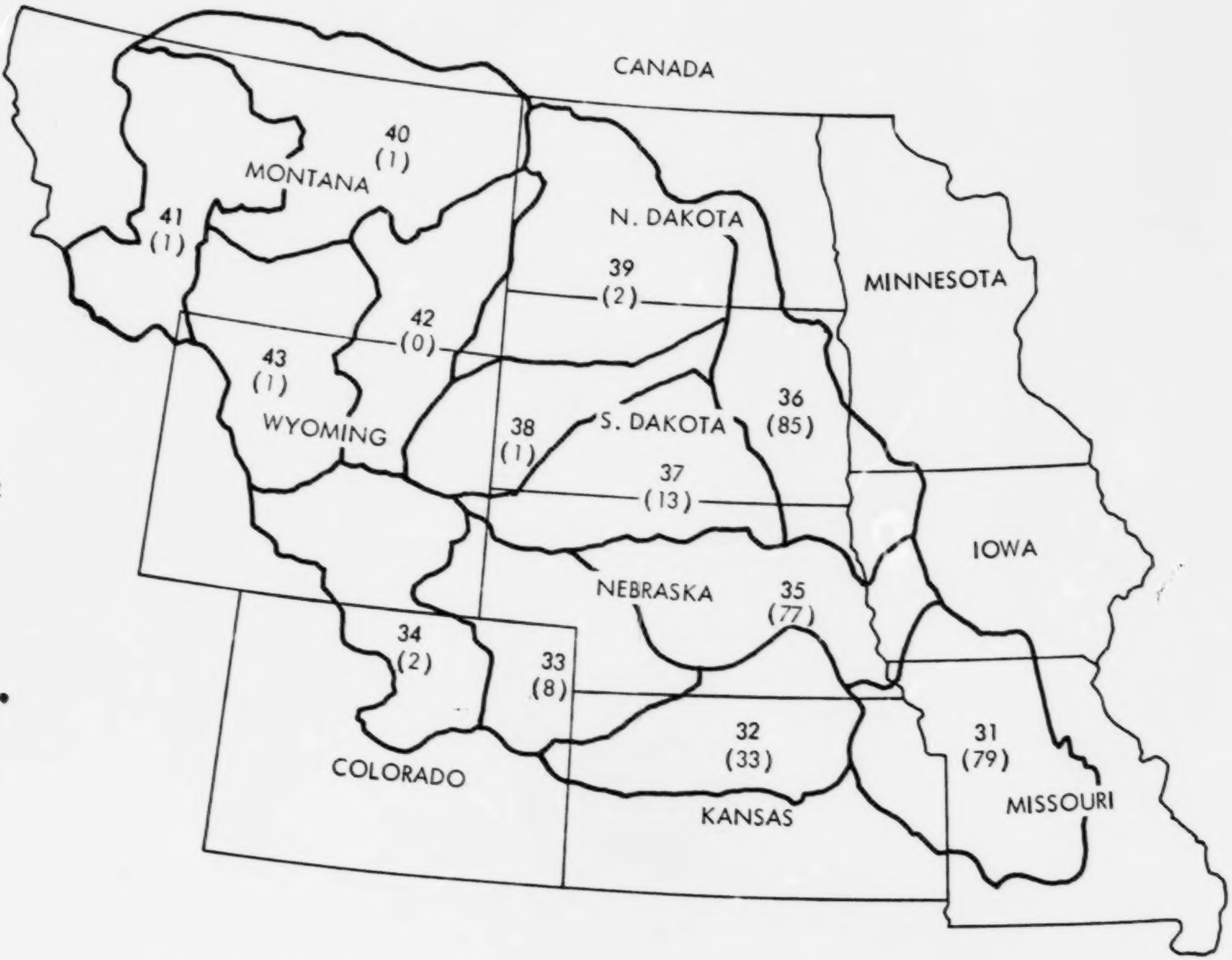

CANADA
U.S.
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WYOMING
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
114°
110°
108°
106°
104°
102°
100°
98°
96°
94°
92°
48°
46°
44°
42°
40°
38°
14
18
16
21
22
26
24
26
26
27
22
26
35
23
11
11
11
19
23
14
13
11
13
11
13
14
14
15
24
27
44
45
22
48
56
25
66
58
83
21
30
23
23
70
78
31
136
42
123
28
20
25
19
55
74
52
39
48
32
45
45
36
26
39
86
28
101
53
54
105
54
104
164
132
86
121
90
97
92
168
77
102
83
80
91
139
147
127
100
118
125
101
102
110
93
85
95
14
85
44
46
51
76
79
93
84
100
78
76
97
88
98
93
81
84
102
86
88
57
32
50
72
83
89
73
49
53
68
55
49
58
66
7
47
88
92
112
106
57

Figure 5. Distribution of cattle per square mile in Missouri Basin


CANADA
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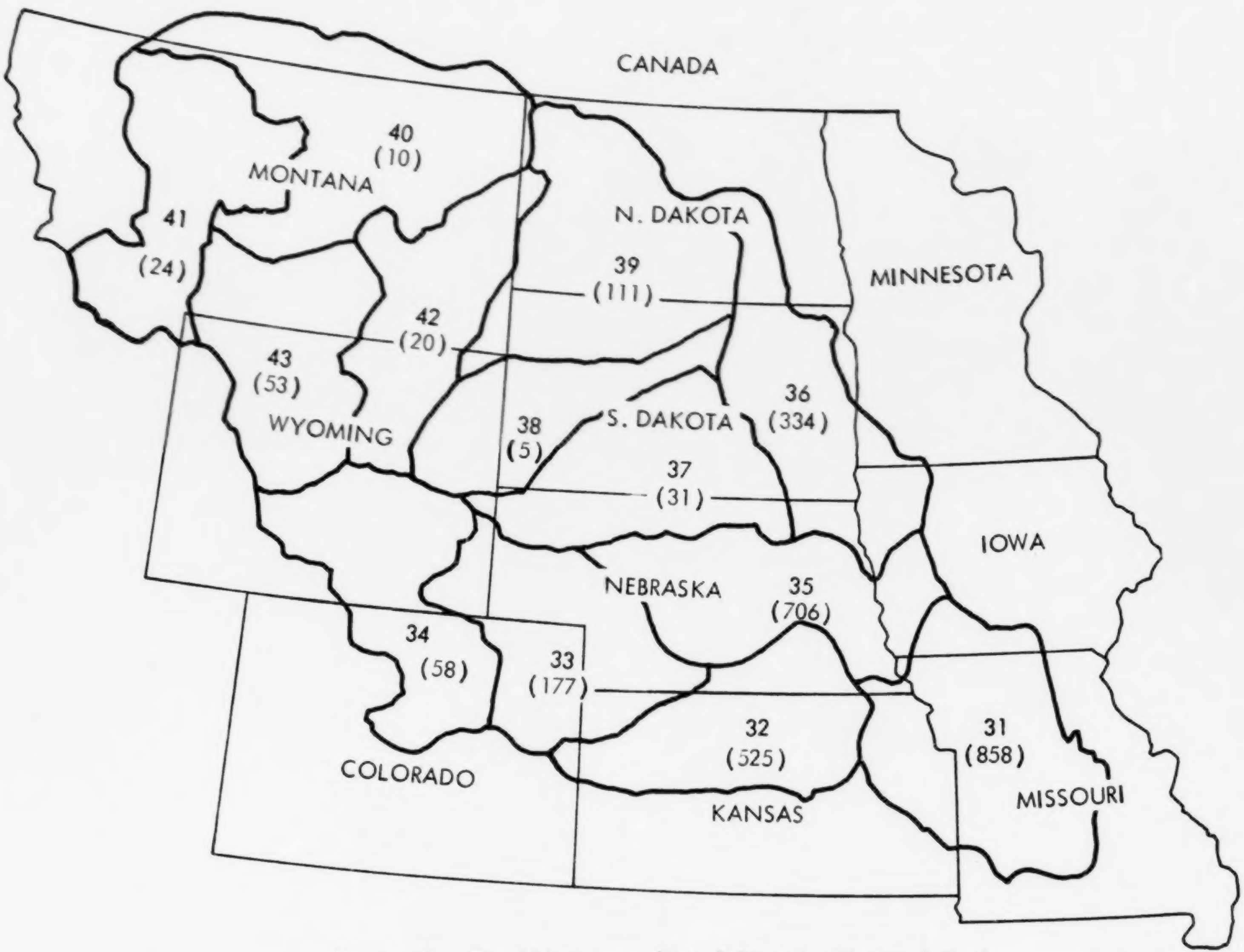
IOWA
MISSOURI
KANSAS
COLORADO
NEBRASKA
N. DAKOTA
S. DAKOTA
WYOMING
MONTANA
40
(1)
41
(1)
39
(2)
42
(0)
43
(1)
38
(1)
36
(85)
37
(13)
35
(77)
34
(2)
33
(8)
32
(33)
31
(79)

Figure 6. Distribution of hogs per square mile in Missouri Basin, Station Mean Values (basin average = 34)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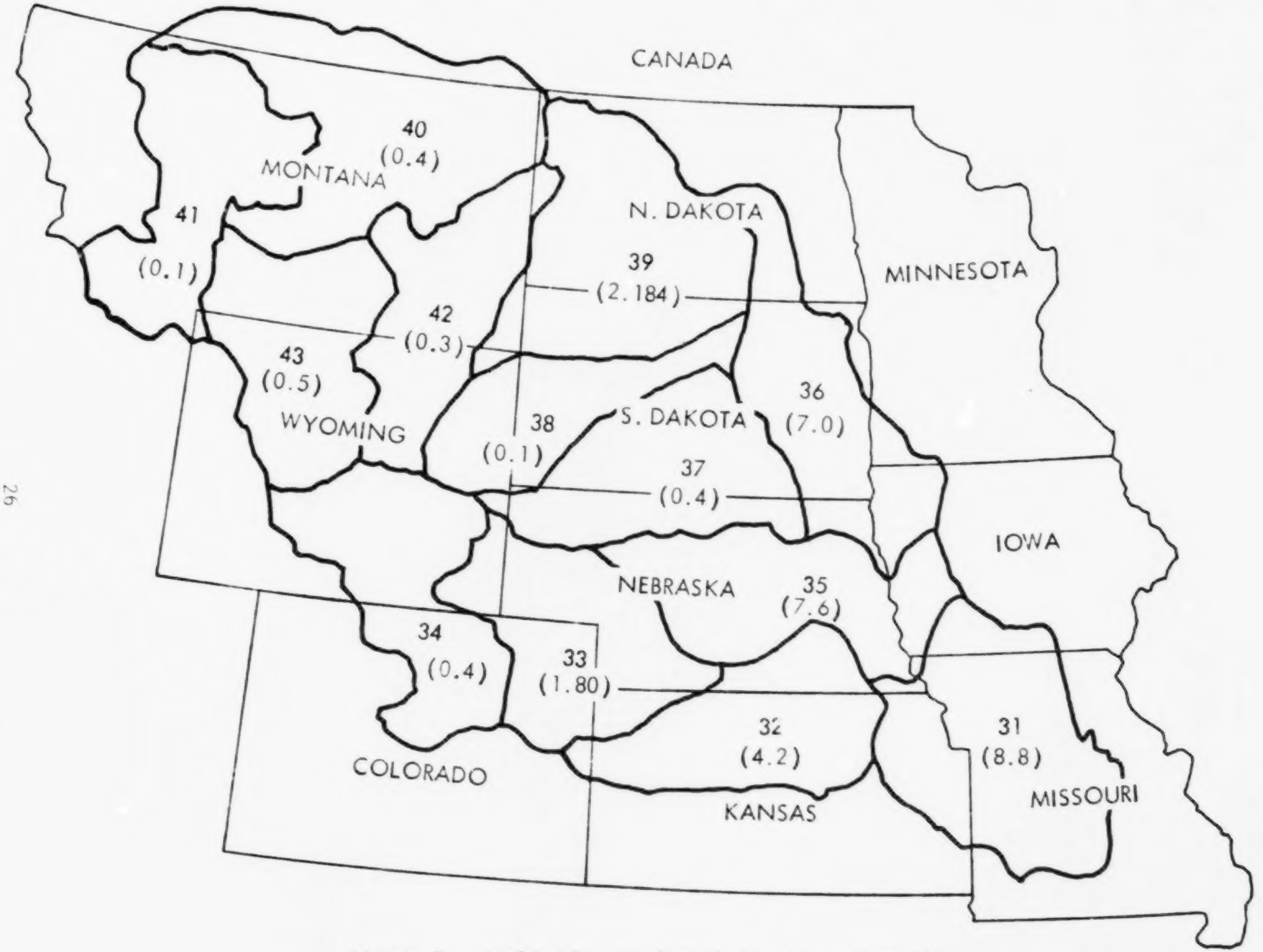
(10)
41
(24)
N. DAKOTA
39
(111)
MINNESOTA
42
(20)
43
(53)
WYOMING
38
(5)
S. DAKOTA
36
(334)
37
(31)
IOWA
NEBRASKA
35
(706)
34
(58)
33
(177)
32
(525)
31
(858)
COLORADO
KANSAS
MISSOURI

Figure 7. Fertilizer use (N and PO_4) in Missouri Basin (values shown are 1,000's of tons)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MONTANA
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N. DAKOTA
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(2.184)
MINNESOTA
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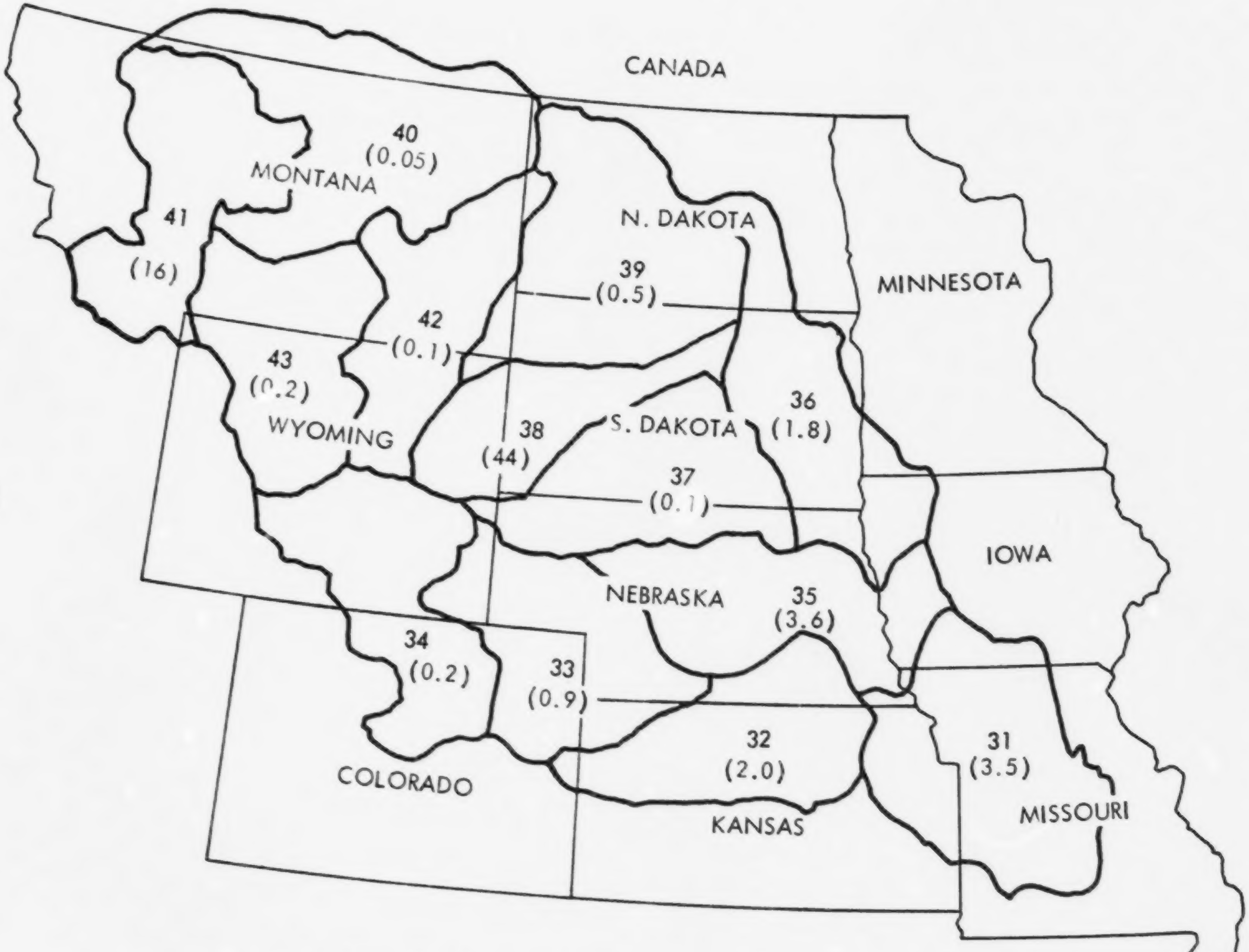
(0.3)
43
(0.5)
WYOMING
38
(0.1)
S. DAKOTA
36
(7.0)
37
(0.4)
IOWA
NEBRASKA
35
(7.6)
34
(0.4)
33
(1.80)
32
(4.2)
31
(8.8)
COLORADO
KANSAS
MISSOURI

Figure 8. Herbicide use (tons) in Missouri Basin
(values shown in 1,000's of tons)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MONTANA
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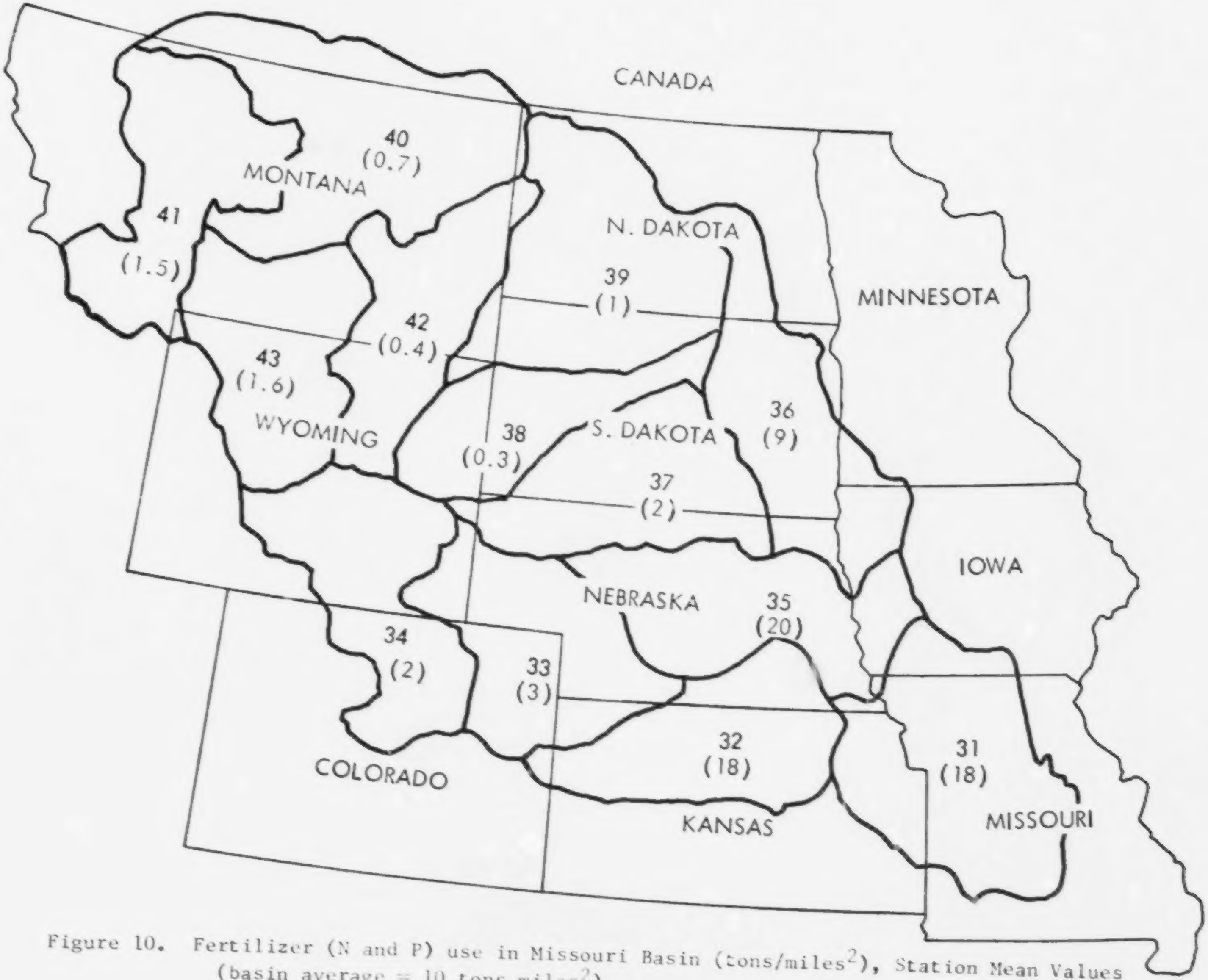
(16)
N. DAKOTA
39
(0.5)
MINNESOTA
42
(0.1)
43
(0.2)
WYOMING
38
(44)
S. DAKOTA
36
(1.8)
37
(0.1)
IOWA
NEBRASKA
35
(3.6)
34
(0.2)
33
(0.9)
32
(2.0)
31
(3.5)
COLORADO
KANSAS
MISSOURI

Figure 9. Insecticide (tons) use in Missouri Basin
(values shown are in 1,000's of tons)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N. DAKOTA
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(1)
MINNESOTA
42
(0.4)
43
(1.6)
WYOMING
38
(0.3)
S. DAKOTA
36
(9)
37
(2)
IOWA
NEBRASKA
35
(20)
34
(2)
33
(3)
32
(18)
31
(18)
COLORADO
KANSAS
MISSOURI

Figure 10. Fertilizer (N and P) use in Missouri Basin (tons/miles^2), Station Mean Values (basin average = 10 tons miles^2)

Table 3. WATER QUALITY IN MISSOURI BASIN

Subbasin No.	Coliforms (No./100 ml)	DO (mg/ℓ)	BOD (mg/ℓ)	Turbidity JU	Total filterable residue (DS) (mg/ℓ)	NO_3 (mg/ℓ)	P, total (mg/ℓ)	Number of water quality stations
31	32,799	8.181	4.075	216.936	312.747	4.047	0.281	28
32	5,509	9.253	4.451	272.283	623.855	3.710	0.092	41
33	386	9.090	2.991	115.361	724.145	3.433	-	20
34	18,847	6.492	4.184	72.481	483.395	1.776	-	27
35	201,326	8.998	15.646	588.911	672.784	5.421	2.369	32
36	3,607	9.594	7.462	80.363	643.272	1.643	0.944	18
37	5,542	9.000	4.941	629.695	1,076.400	4.330	4.833	9
38	10,029	8.048	5.574	449.586	1,657.689	3.234	-	9
39	47	9.108	1.158	39.778	879.055	0.578	0.045	5
40	6,675	8.699	1.802	97.400	567.904	0.313	-	4
41	-	-	-	-	362.306	0.539	-	5
42	5,092	8.919	3.260	1,262.149	1,687.281	1.410	0.167	11
43	1,332	10.120	1.598	20.272	407.031	0.717	0.228	24
Mean for the basin	24,266	8.669	6.819	327.090	776.758	2.672	1.169	(233)

Specific pollutant loading rates were computed for five selected water quality parameters, viz., DO, BOD, NO_3, P, and DS. These rates, expressed in units of pounds of pollutant per square mile of land per day, are presented in Table 4 for each of the subbasins and the whole basin. These values were computed for each water quality monitoring station from the pollutant concentration (mg/liter) and stream flow (ft [illegible]) and land area of watershed ($mile^2$) represented by that station. The number of stations selected for each subbasin are also presented. "Loading rates" for DO are included in Table 4. DO and BOD are usually inversely related. However, DO is also related to other stream parameters, e.g., phytoplankton, sediments, and temperature.

Table 5 presents a summary of both water quality concentrations and pollutant loading rates for seven parameters. These parameters include DO, BOD, turbidity, dissolved solids, nitrate, total phosphorus, and coliforms. The units for each of the parameters are also shown in Table 5.

Figures 11 through 17 show the distribution of selected water quality parameters in the basin. These parameters include concentrations of dissolved oxygen (Figure 11), nitrate (Figure 12), BOD (Figure 13), total coliforms (Figure 14), turbidity (Figure 15), and dissolved solids (Figure 16). Figure 17 shows BOD in pounds per day per square mile in the basin.

Subbasin 35 shows the highest concentration for all pollutants except turbidity. Subbasins 31, 35, and 38 show lower dissolved oxygen concentrations than the basin average. Nitrate concentration is higher than the basin average in subbasins 31, 32, 33, 35, 37, and 38. BOD concentration is higher in subbasins 35 and 36, while total coliforms concentrations show higher values in subbasins 31 and 35 than the basin average. Turbidity values show that subbasins 35, 37, 38, and 42 have above average values.

STREAM WATER QUALITY CHARACTERISTICS

Water quality data for 1969 in the Missouri River and other streams in the basin were analyzed in terms of DO, BOD, NO_3, and total P, as a function of location of water quality monitoring stations. Eleven graphs (Figures 18 through 28) are presented for these parameters as well as flowrate in the streams. Some of the streams which were also analyzed but not graphically presented showed generally good water quality in terms of the above parameters, but did not contain sufficient data for analysis. The following streams were analyzed in detail:

Missouri River
Yellowstone River
Bighorn River

Table 4. POLLUTANT BURDEN IN MISSOURI BASIN (lb/mile^2/day)

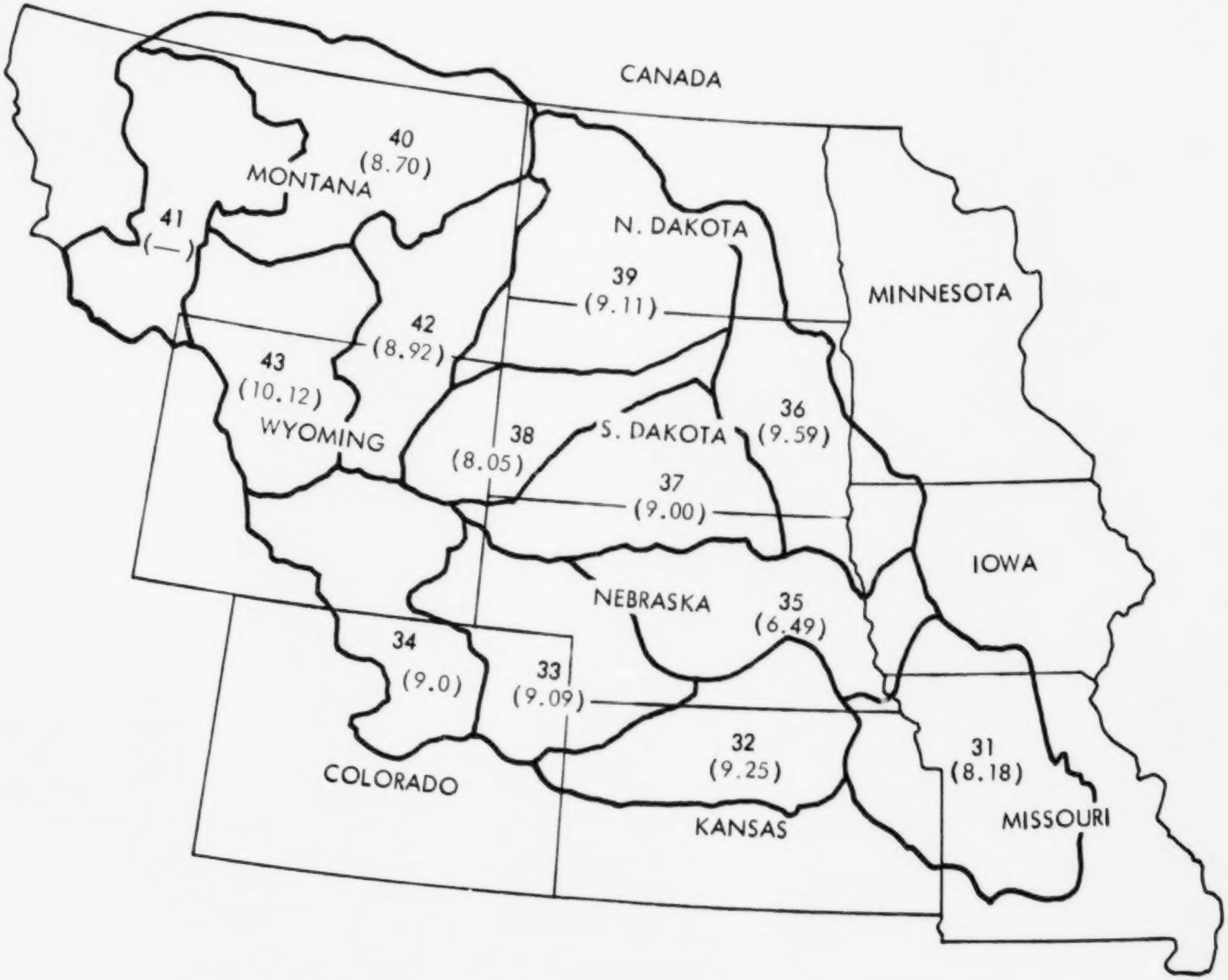
Subbasin No.	DO[a]	BOD	NO_3	P	DS
31	168.103	149.900	113.065	54.624	6,665
32	71.855	46.418	29.186	0.735	2,737
33	7.933	0.482	1.749	-	260
34	25.149	7.969	7.125	-	173
35	68.055	75.771	22.194	6.351	2,070
36	15.856	9.989	28.611	-	1,380
37	0.970	0.311	0.201	-	108
38	11.554	7.767	3.837	-	1,042
39	-	-	0.071	-	116
40	16.249	3.366	0.424	-	589
41	-	-	1.214	-	1,107
42	18.22	6.66	1.658	0.633	1,602
43	180.619	21.858	8.154	4.125	4,028
Average for the basin	88.548	40.091	23.221	12.136	2,493

---

[a] DO is included here as a water quality parameter rather than as a pollutant.

Table 5. SUMMARY OF WATER QUALITY AND POLLUTANT BURDEN IN MISSOURI RIVER BASIN

	Water quality concentrations		Pollutant burden	
Parameter	Mean concentration	Unit	Mean value	Unit
DO	8.70	mg/liter	88.5	lb/miles^2/day
BOD	6.82	mg/liter	40.1	lb/miles^2/day
Turbidity	327	JU	0.58	JU/miles^2
Dissolved solids	777	mg/liter	2,464	lb/miles^2/day
Nitrate (NO_3)	2.67	mg/liter	23.2	lb/miles^2/day
Total phosphorus	1.17	mg/liter	12.1	lb/miles^2/day
Coliforms	24,266	No./100 ml		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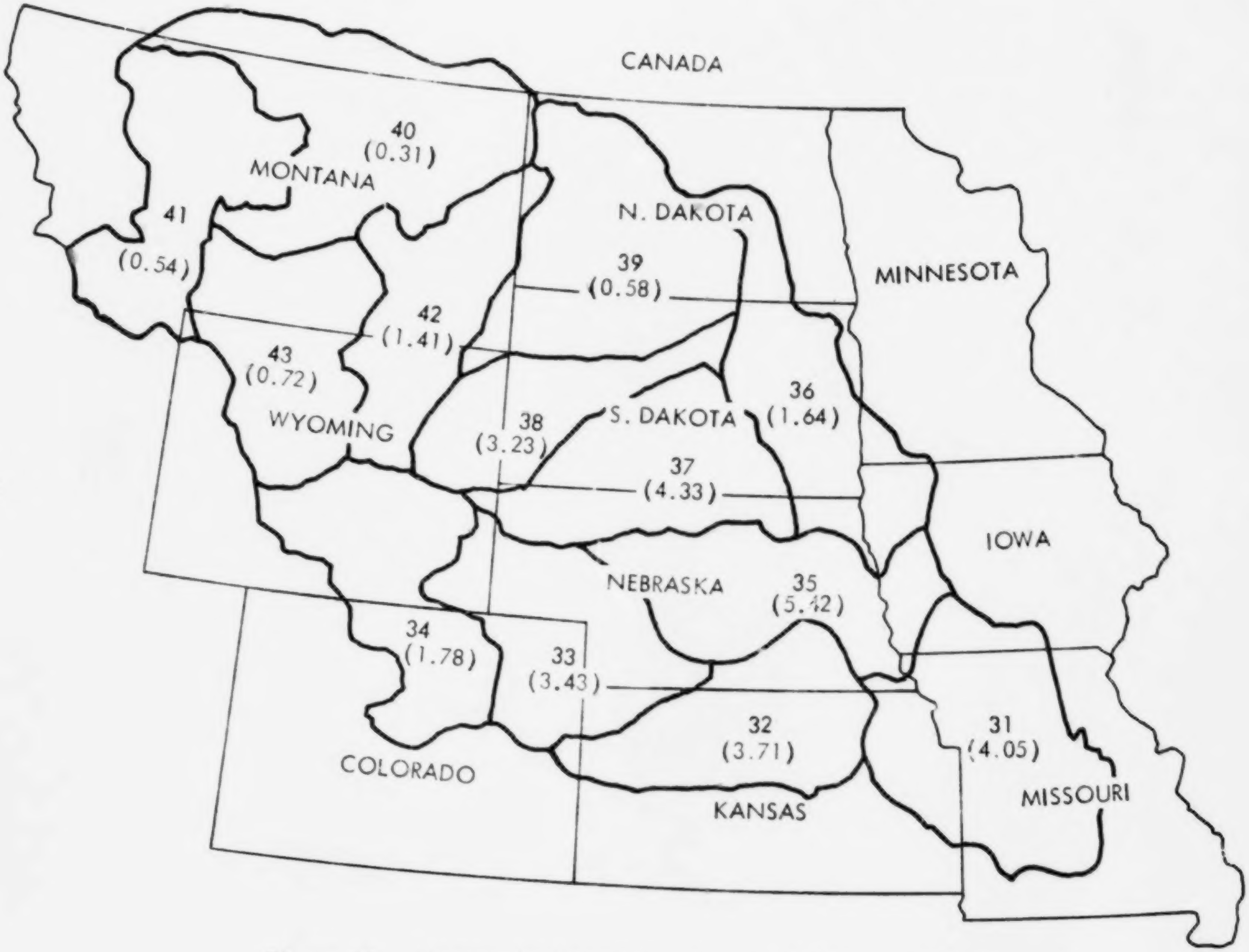
MONTANA
41
(—)
N. DAKOTA
39
(9.11)
MINNESOTA
42
(8.92)
43
(10.12)
WYOMING
38
(8.05)
S. DAKOTA
36
(9.59)
37
(9.00)
IOWA
NEBRASKA
35
(6.49)
34
(9.0)
33
(9.09)
32
(9.25)
31
(8.18)
COLORADO
KANSAS
MISSOURI

Figure 11. Dissolved oxygen (mg/liter) in streams of Missouri Basin (basin average = 8.67)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MONTANA
41
(0.54)
N. DAKOTA
39
(0.58)
MINNESOTA
42
(1.41)
43
(0.72)
WYOMING
36
(1.64)
38
(3.23)
S. DAKOTA
37
(4.33)
IOWA
NEBRASKA
35
(5.42)
34
(1.78)
33
(3.43)
32
(3.71)
31
(4.05)
COLORADO
KANSAS
MISSOURI

Figure 12. Nitrate (mg/liter) in streams of Missouri Basin
(basin average = 2.67 mg/liter)

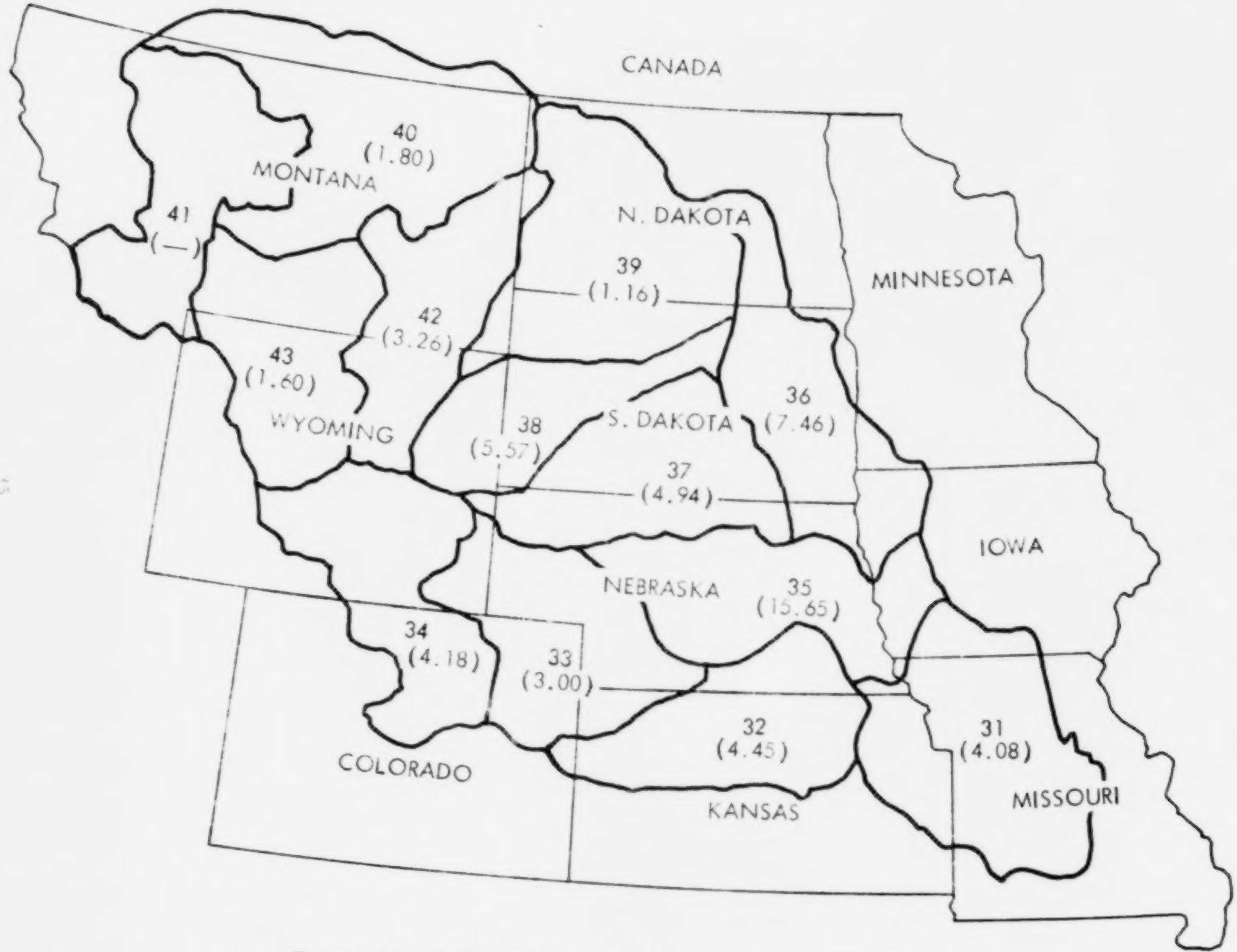
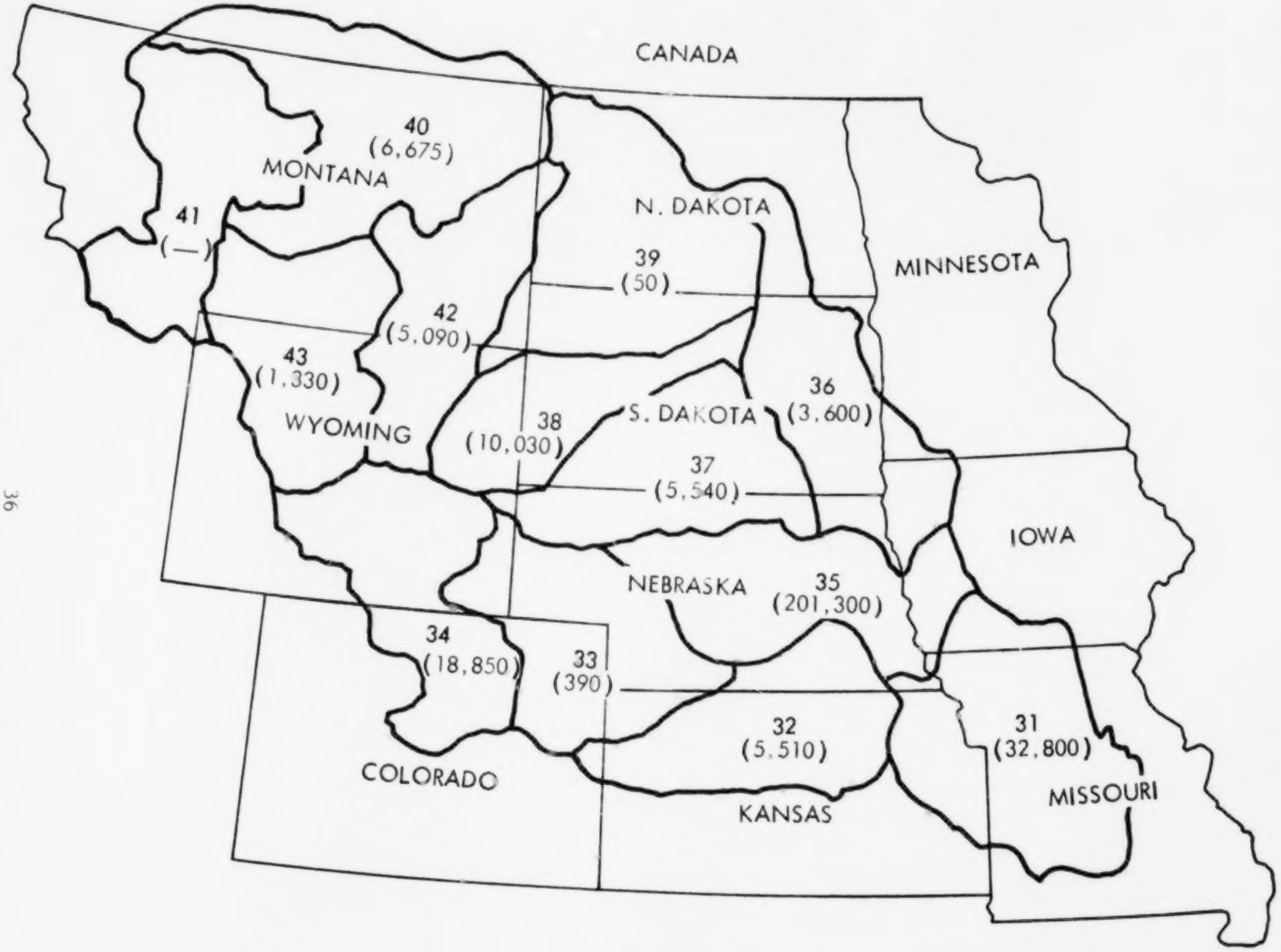

CANADA
MINNESOTA
IOWA
MISSOURI
N. DAKOTA
S. DAKOTA
NEBRASKA
KANSAS
COLORADO
WYOMING
MONTANA
40
(1.80)
41
(—)
42
(3.26)
43
(1.60)
39
(1.16)
38
(5.57)
36
(7.46)
37
(4.94)
35
(15.65)
34
(4.18)
33
(3.00)
32
(4.45)
31
(4.08)

Figure 13. BOD (mg/liter) in streams of Missouri Basin
(basin average = 6.82 mg/liter)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MONTANA
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(—)
N. DAKOTA
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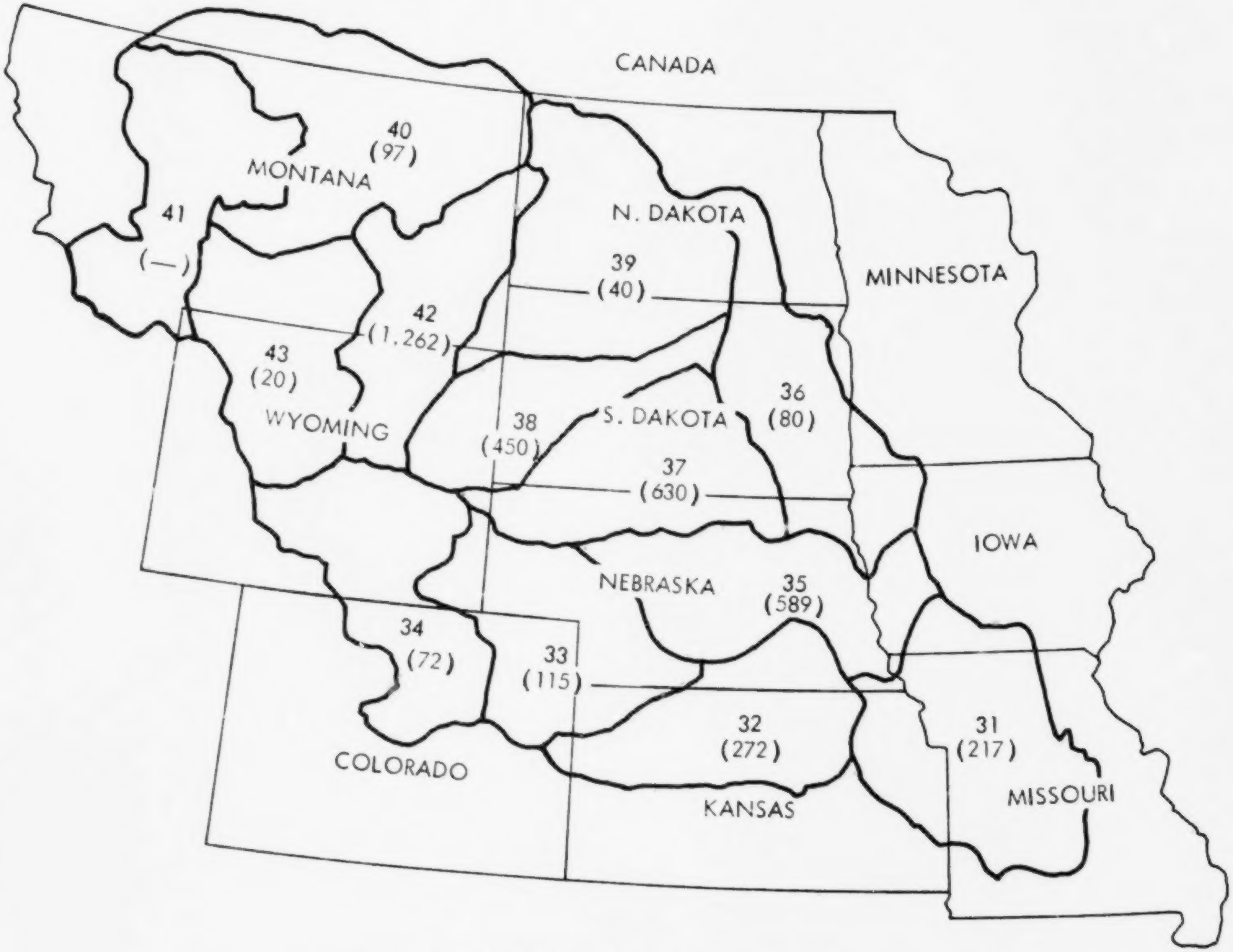
(50)
MINNESOTA
42
(5,090)
43
(1,330)
WYOMING
38
(10,030)
S. DAKOTA
36
(3,600)
37
(5,540)
IOWA
NEBRASKA
35
(201,300)
34
(18,850)
33
(390)
32
(5,510)
31
(32,800)
COLORADO
KANSAS
MISSOURI

Figure 14. Total coliform (No./100 ml) in streams of Missouri Basin
(basin average = 24,266)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(97)
MONTANA
41
(—)
N. DAKOTA
39
(40)
MINNESOTA
42
(1,262)
43
(20)
WYOMING
38
(450)
S. DAKOTA
36
(80)
37
(630)
IOWA
NEBRASKA
35
(589)
34
(72)
33
(115)
32
(272)
31
(217)
COLORADO
KANSAS
MISSOURI

Figure 15. Turbidity (JU) in streams of Missouri Basin
(basin average = 327)

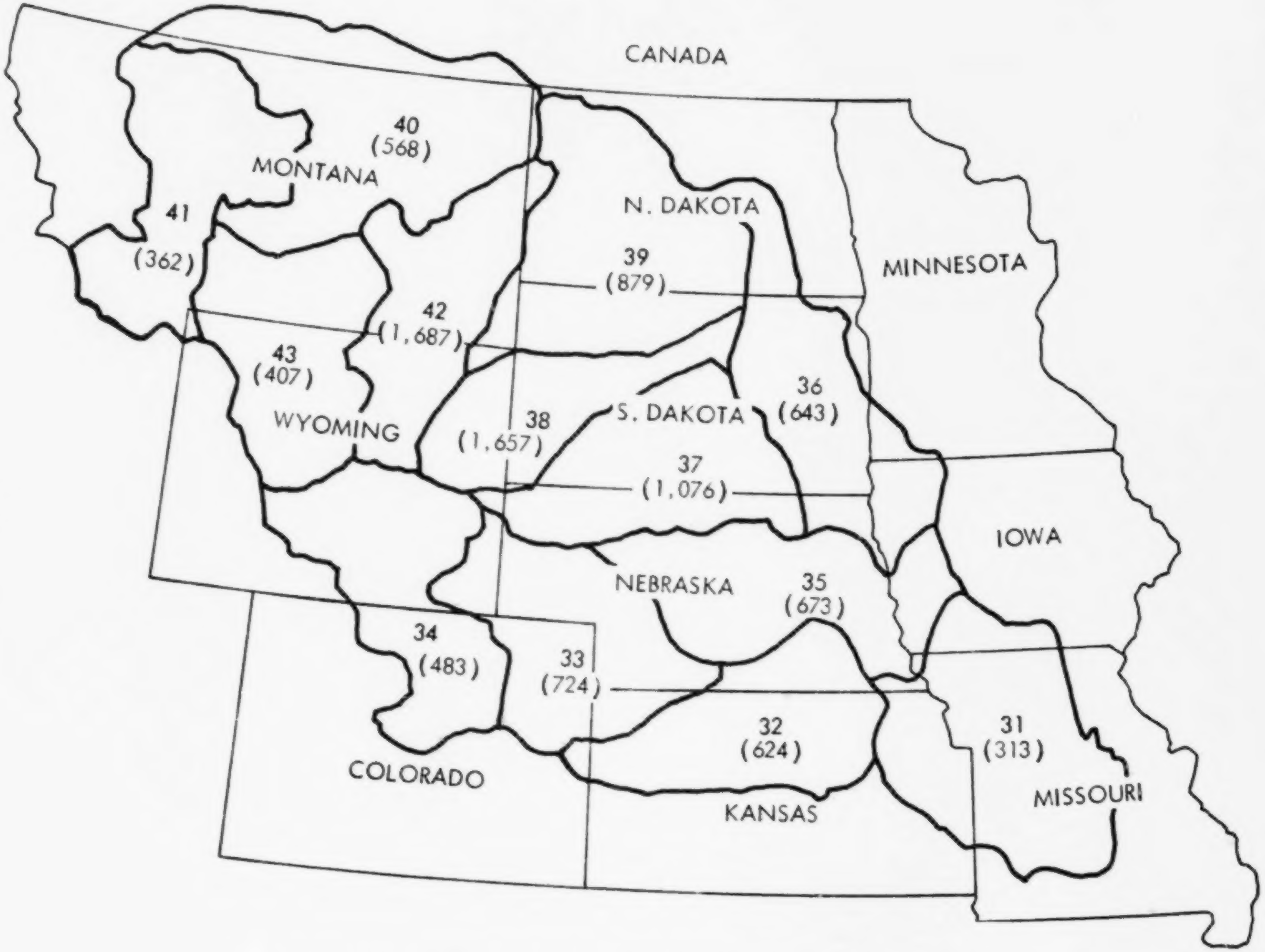
CANADA
MONTANA
40
(568)
41
(362)
N. DAKOTA
39
(879)
MINNESOTA
42
(1,687)
43
(407)
36
(643)
S. DAKOTA
38
(1,657)
WYOMING
37
(1,076)
IOWA
NEBRASKA
35
(673)
34
(483)
33
(724)
32
(624)
31
(313)
COLORADO
MISSOURI
KANSAS

Figure 16. Distribution of dissolved solids in Missouri Basin
(basin average = 777 mg/liter)

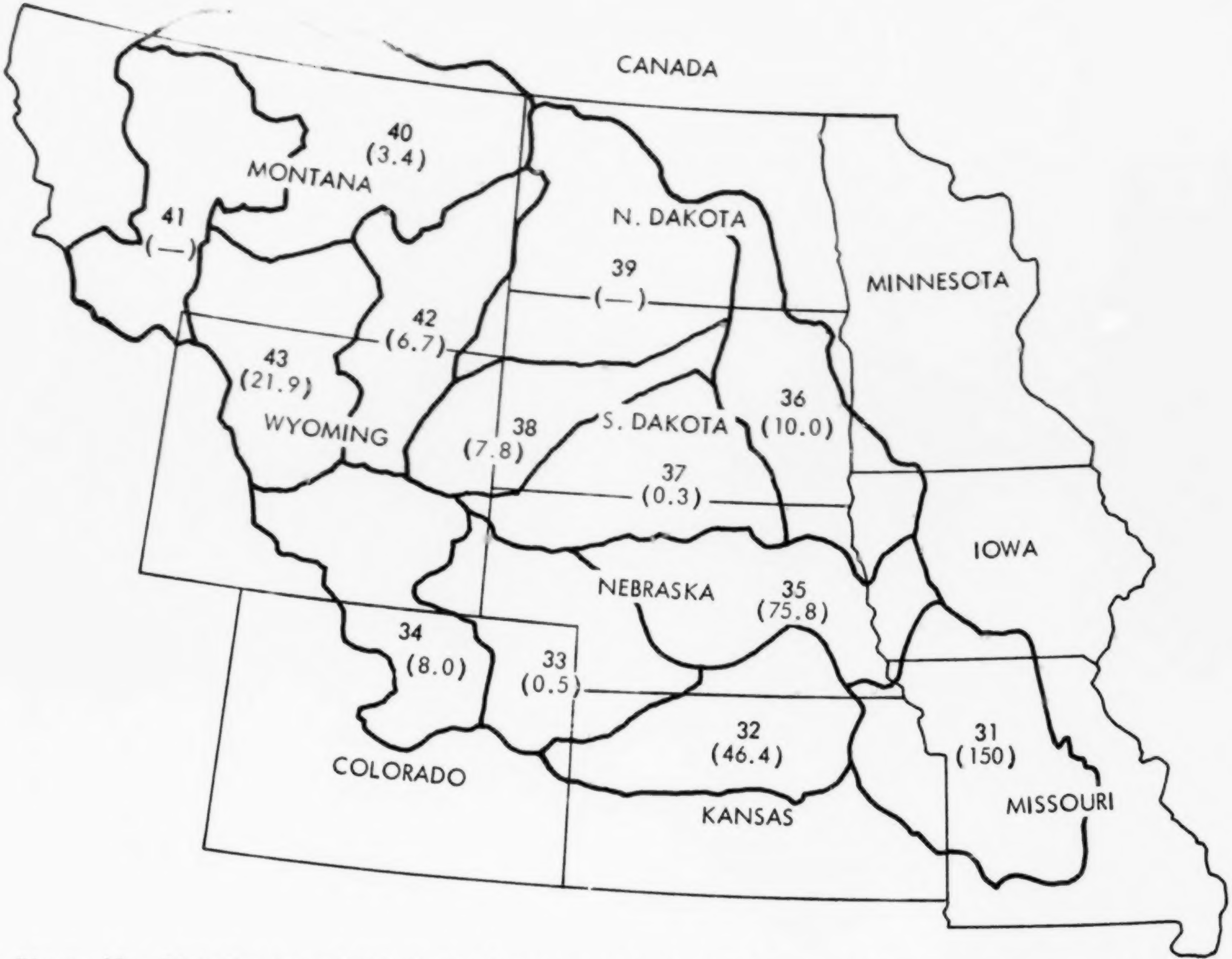
CANADA
MONTANA
N. DAKOTA
MINNESOTA
S. DAKOTA
WYOMING
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
40
(3.4)
41
(—)
42
(6.7)
43
(21.9)
39
(—)
38
(7.8)
36
(10.0)
37
(0.3)
35
(75.8)
34
(8.0)
33
(0.5)
32
(46.4)
31
(150)

Figure 17. Distribution of BOD (lb/day) per square mile in Missouri Basin, Station Mean Values (basin average = 40 lb/day/mile^2)

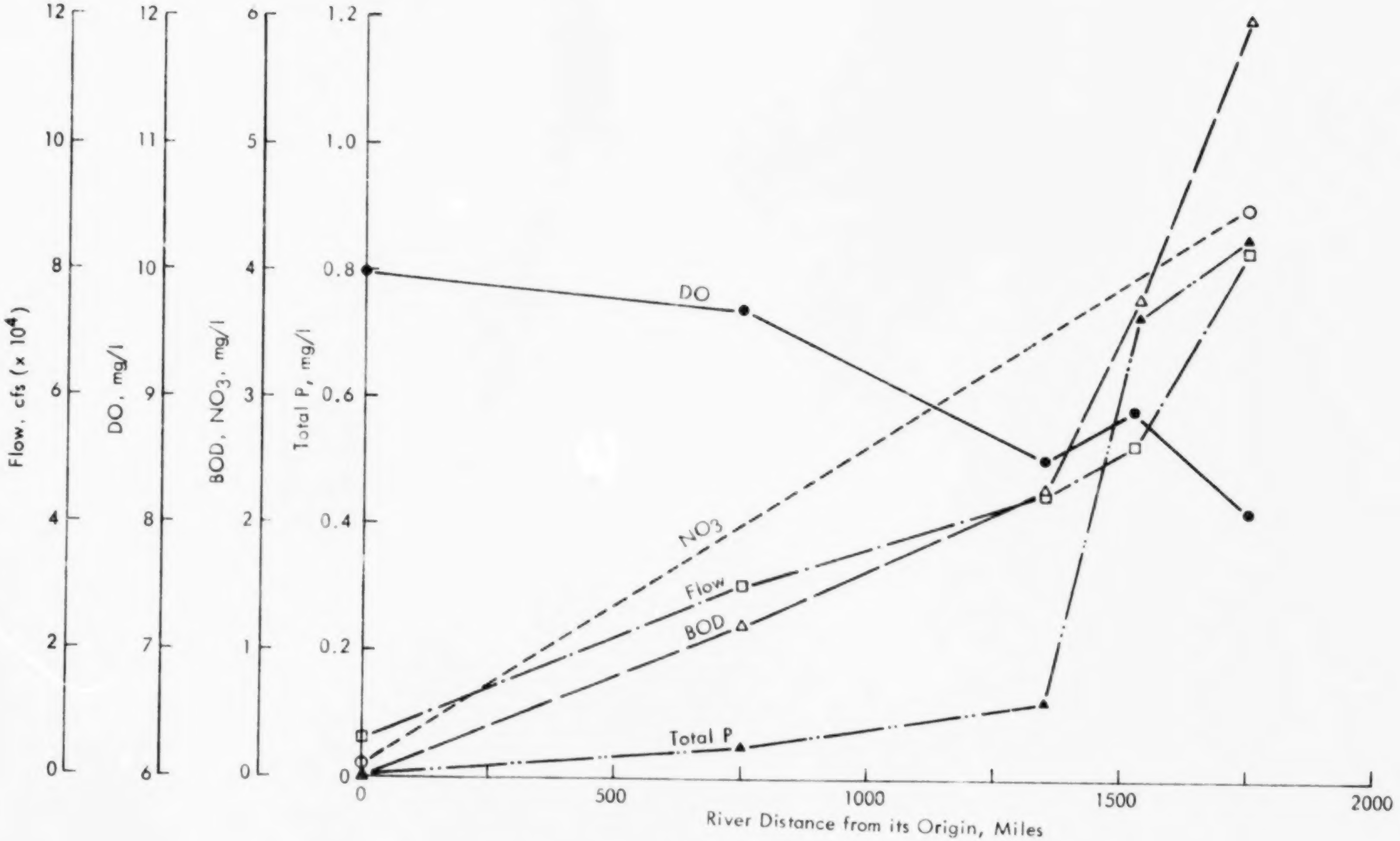

Figure 18. Water quality along the main stem of Missouri River

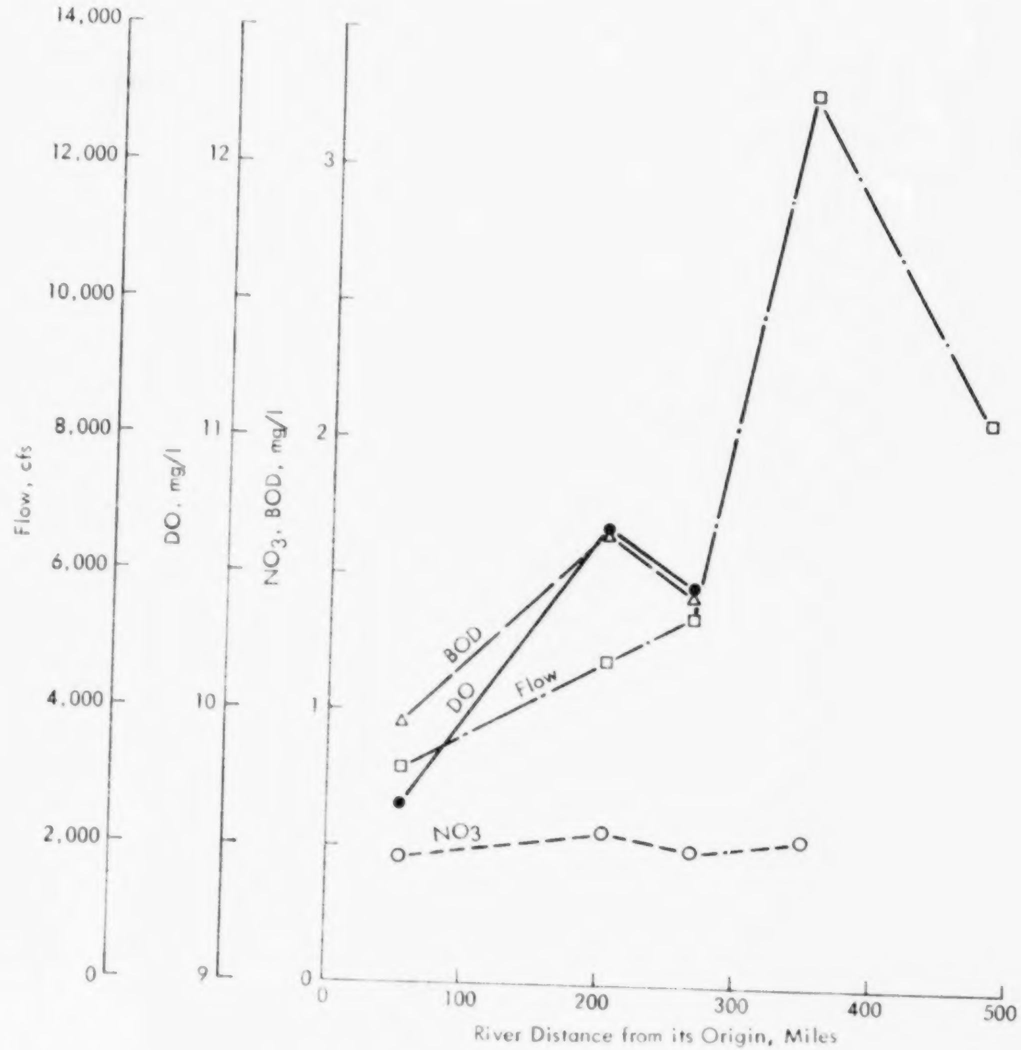

Figure 19. Water quality along Yellowstone River

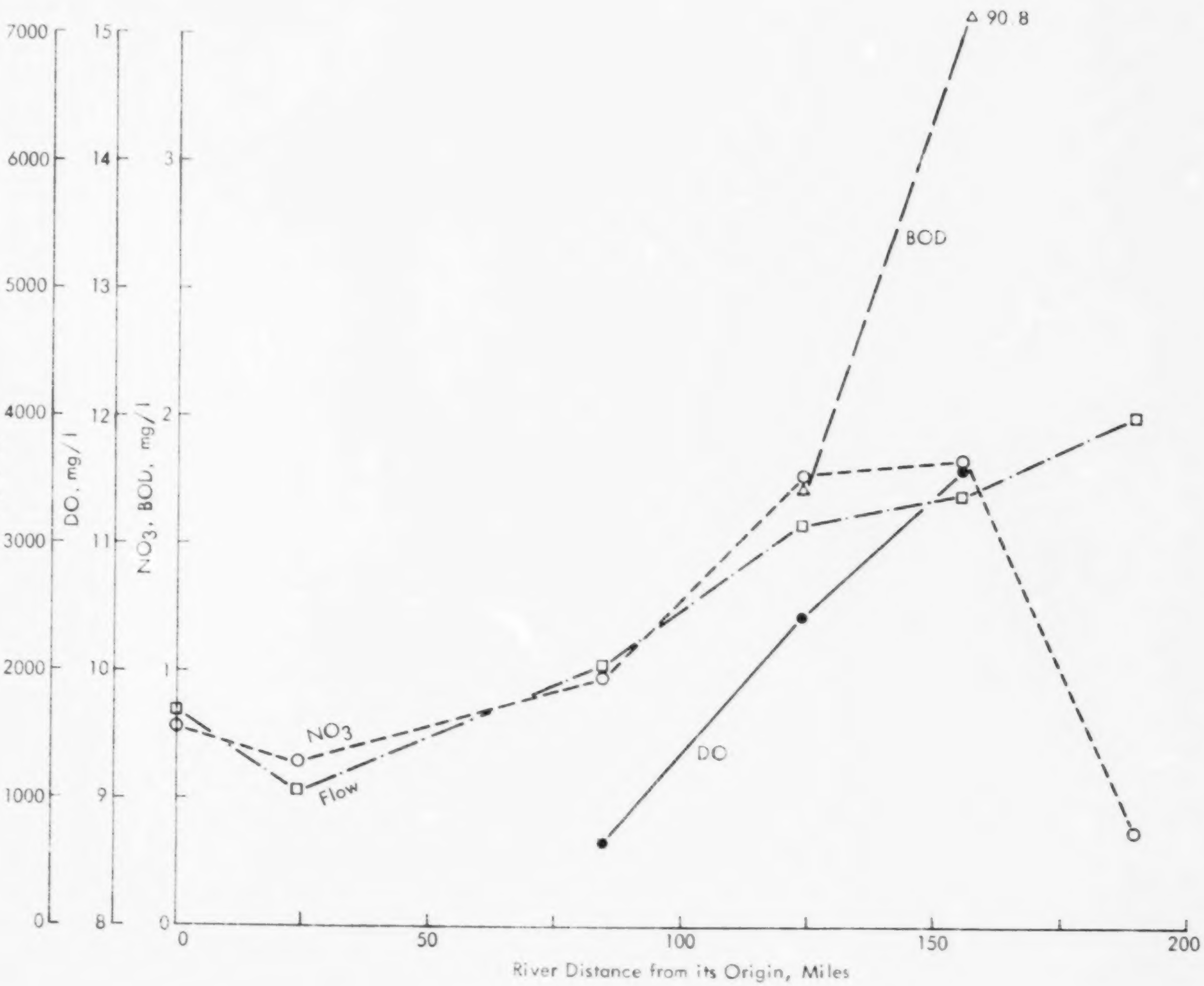

Figure 20. Water quality along Big Horn River

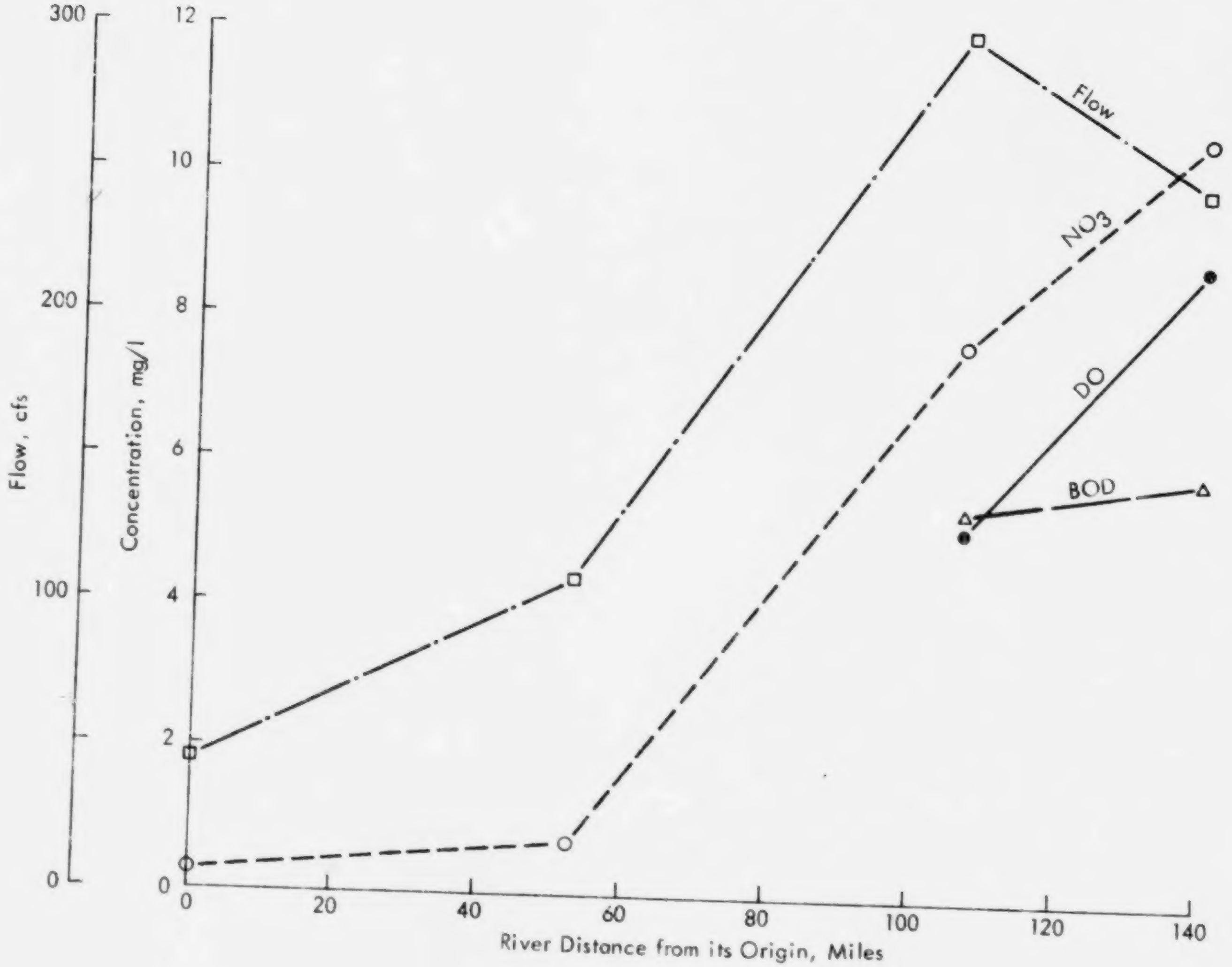

Figure 21. Water quality along Belle Fourche River

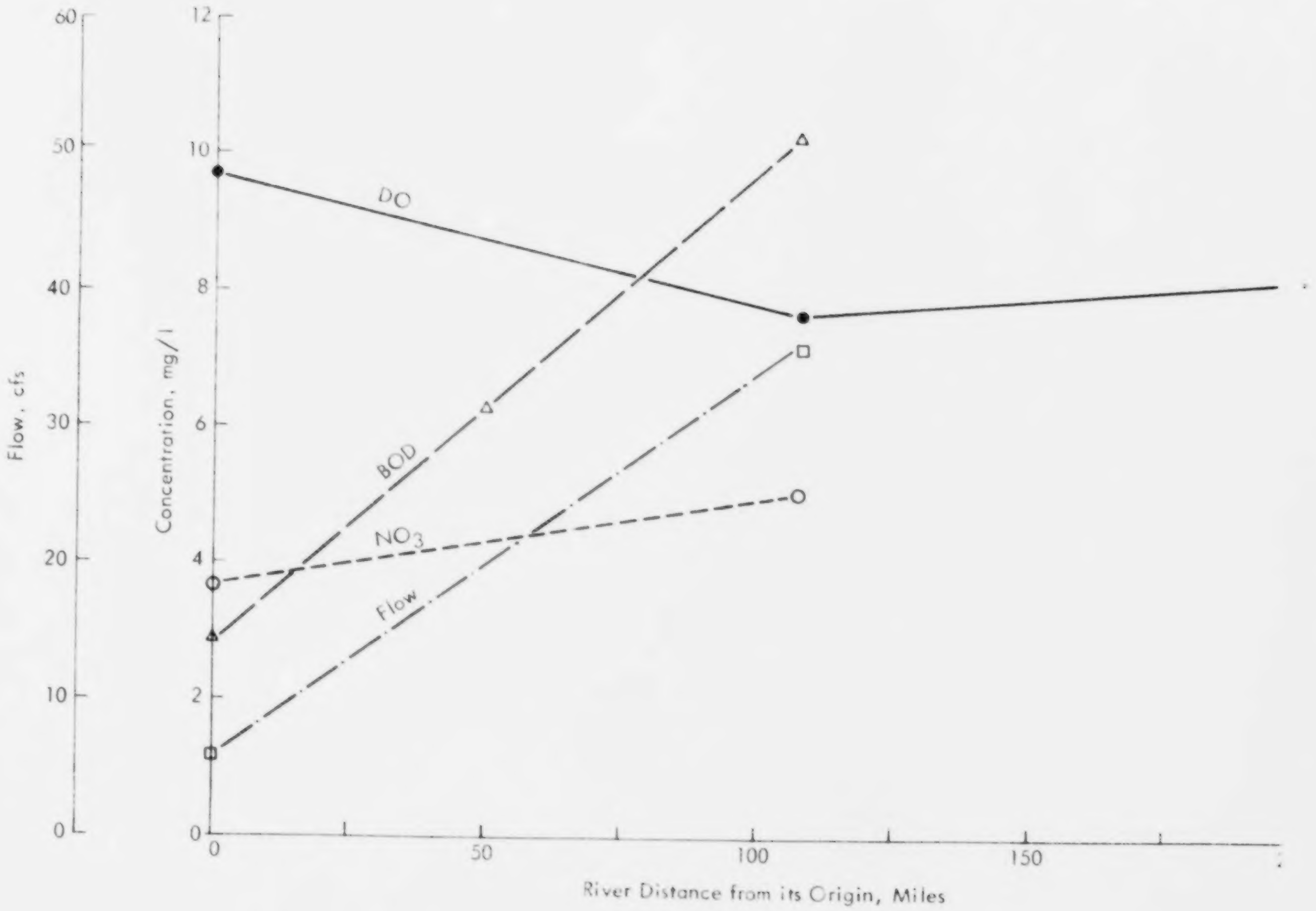

Figure 22. Water quality along White River

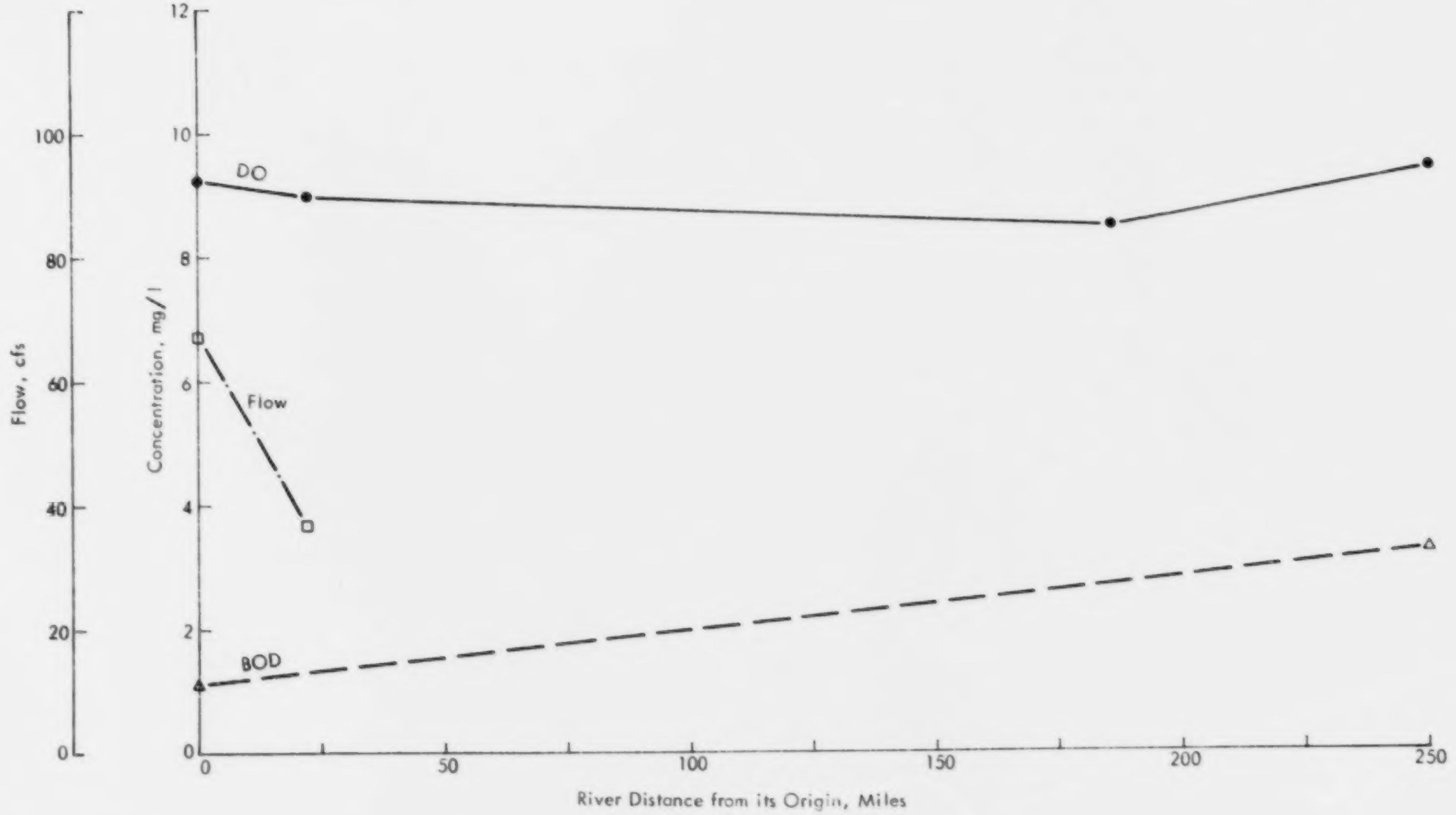

Figure 23. Water quality along Niobrary River

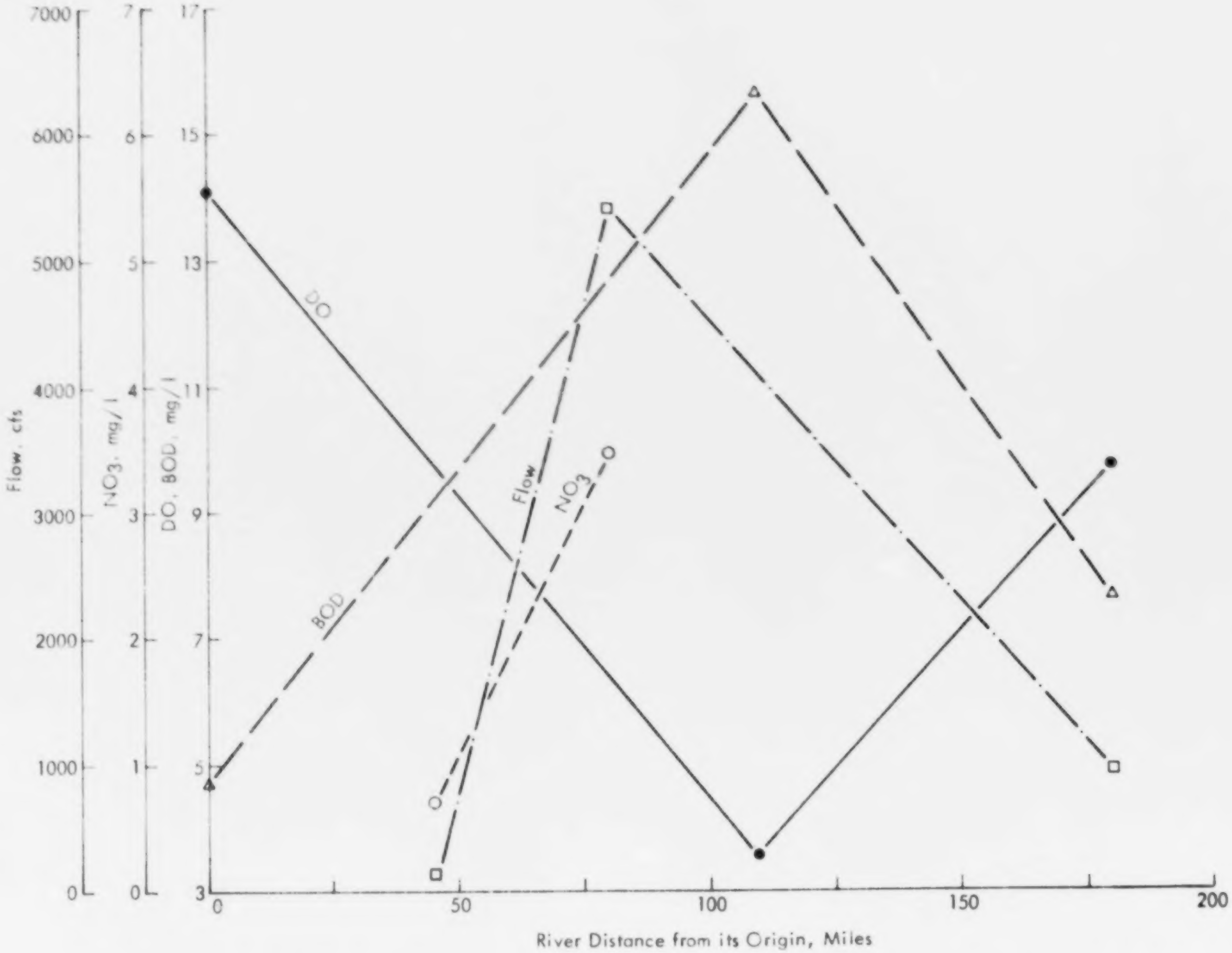

Figure 24. Water quality along Big Sioux River

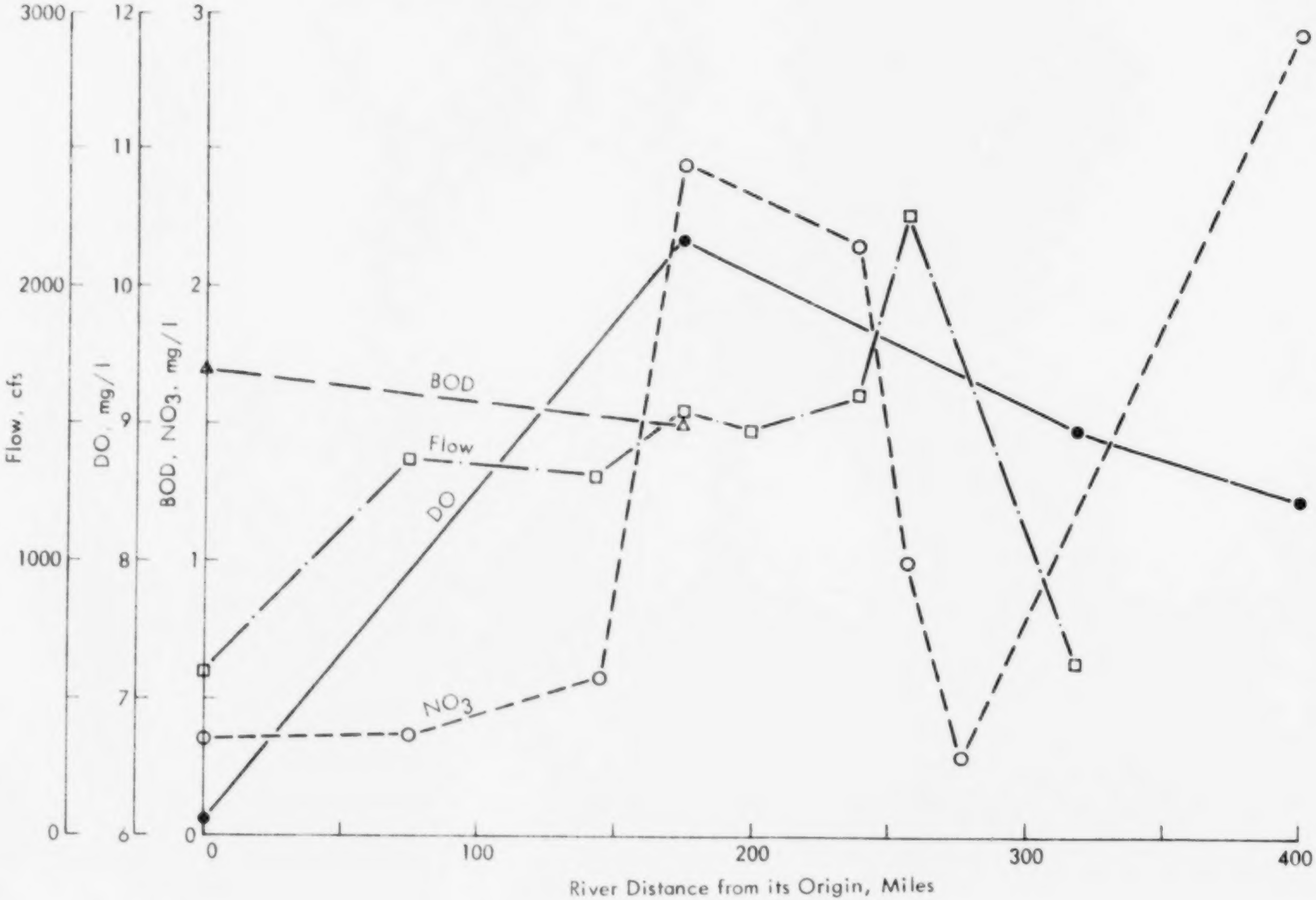

Figure 25. Water quality along North Platte River

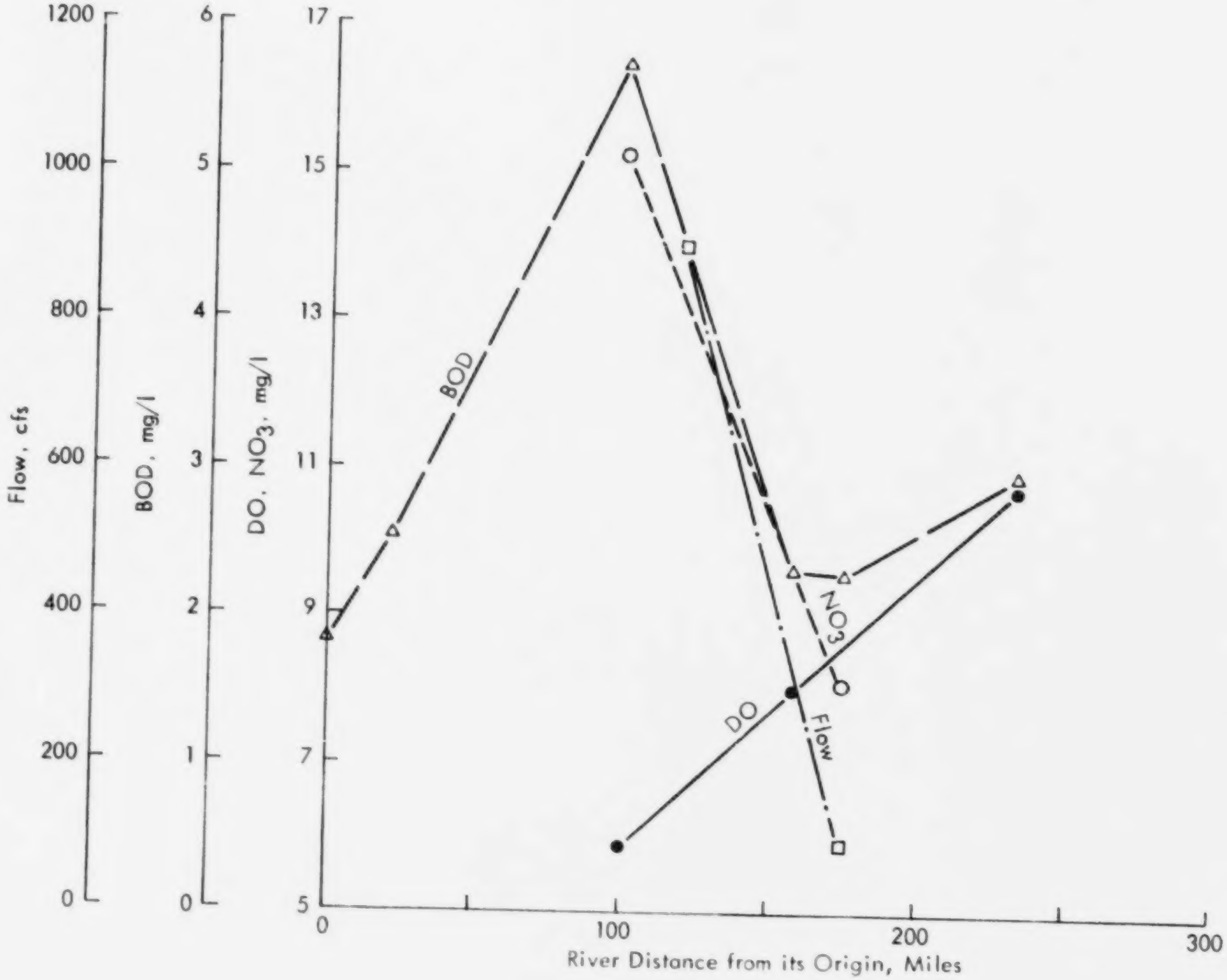

Figure 26. Water quality along South Platte River

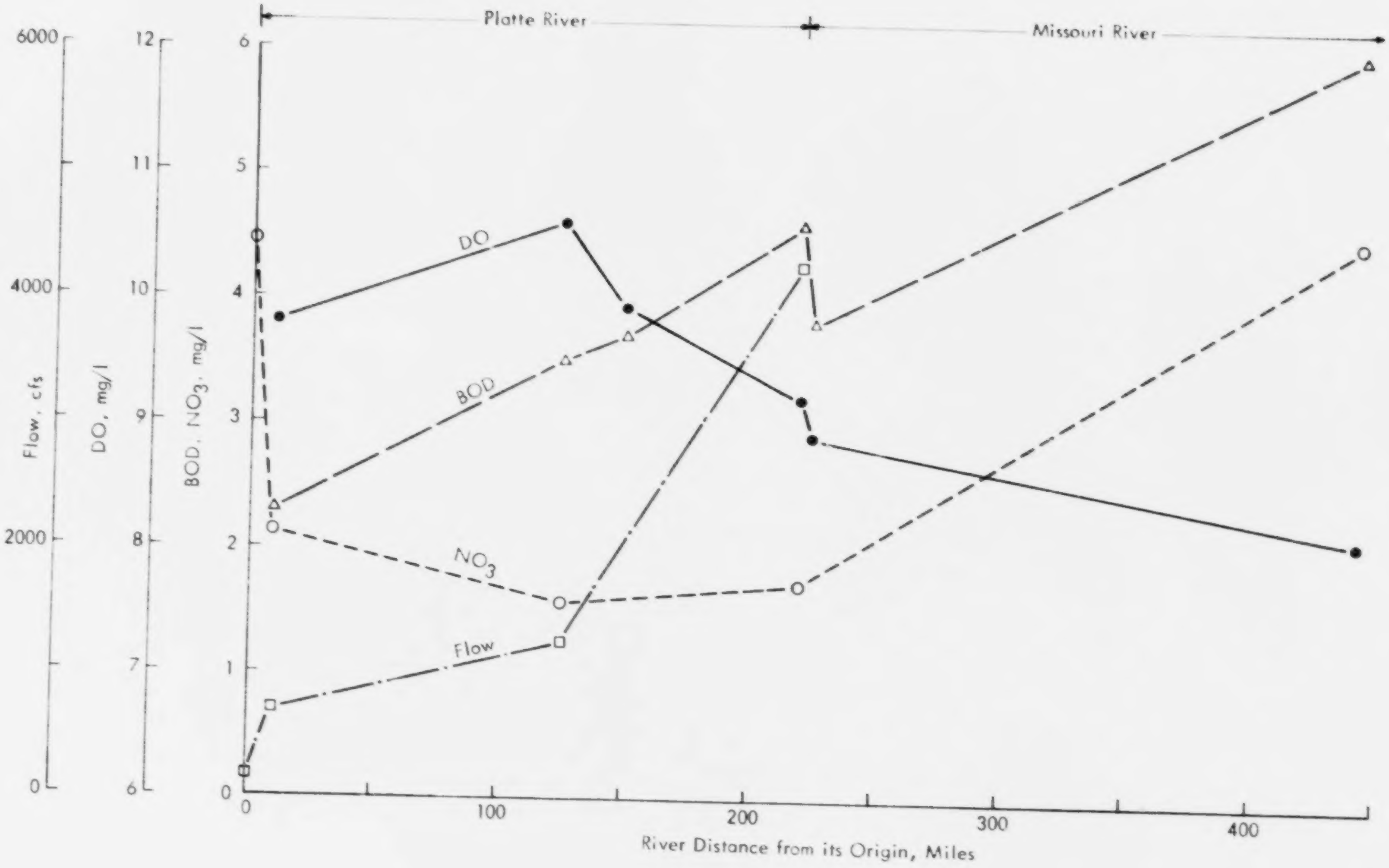

Figure 27. Water quality along Platte River

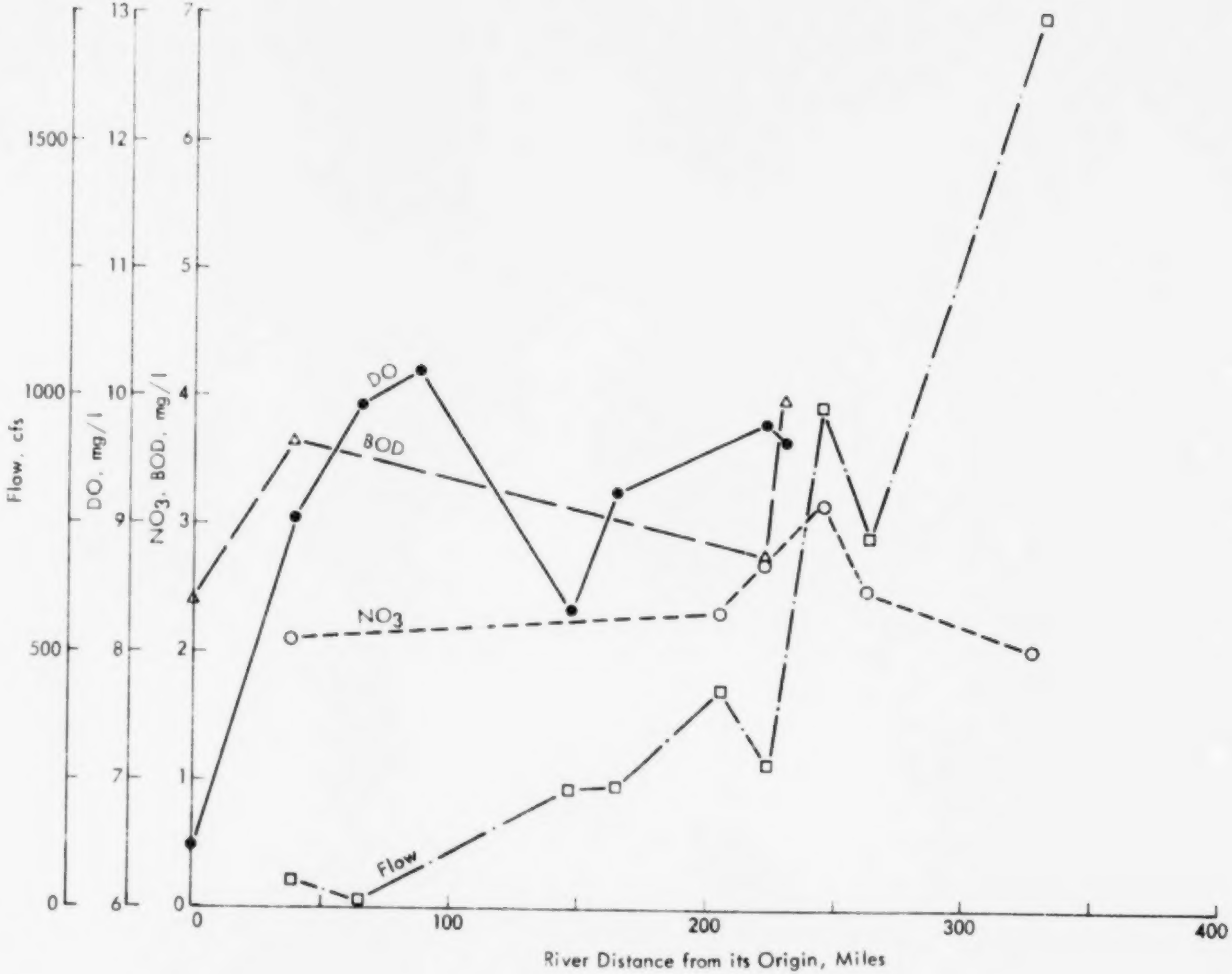

Figure 28. Water quality along Republican River

Belle Fourche River
White River
Niobrara River
Big Sioux River
North Platte River
South Platte River
Platte River
Republican River

The following streams were not analyzed in detail due to lack of adequate data, but were found to possess generally adequate water quality:

Milk River
Powder River
Cheyenne River
James River
Elkhorn River
Loupe River
Lodgepole Creek
Saline River
Smoky Hill River

The following streams were also not analyzed in-depth due to lack of adequate data, but available data appear to indicate that these streams are generally of poor water quality, and that further acquisition of data is warranted:

Elkhorn River (high NO_3)
Kansas River (high NO_3 and DS)
Grand River (high NO_3, very high coliforms)
Moreau River (high coliforms, low DO)
Osage River (high NO_3, coliforms, low DO)

A brief discussion of water quality in the Missouri River and other streams follows.

Missouri River

Five water quality monitoring stations were selected on the main stem of the Missouri River. These were located at Canyon Ferry, Montana (Station No. 1000001); Bismarck, North Dakota (1000006); Omaha, Nebraska (1000011); Kansas City, Kansas (1000016); and Hermann, Missouri (1000021). Water quality data for these widely separated stations are presented in Figure 18.

From Figure 18, it is evident that BOD, total phosphorus, and nitrate concentrations increase downstream, while DO concentration decreases. This trend appears to be more pronounced beyond Omaha, Nebraska (Station No. 1000011). From the flow data, it is evident that both the Platte and Kansas rivers contribute to the flow in the Missouri River on the downstream end of the nearest water quality station.

The increase of pollutant concentrations at and below these two stations indicate that both point sources and nonpoint sources are major contributors to stream pollution. The point source contributions include municipal discharges from urban wastes in the area--Omaha, St. Joseph, and Kansas City--as well as other numerous smaller townships within the drainage basin upstream of the two stations. The nonpoint source contributions appear to be primarily due to feedlots, croplands, and other agricultural activities which are concentrated in the southeastern portion of the basin. However, the amount of pollution contributed by individual point and nonpoint sources cannot be computed from the current Data Bank due to a lack of data for point sources.

Yellowstone River

A major tributary of the Missouri River, the Yellowstone River originates near Yellowstone Lake in northwest Wyoming, flows northeasterly through Montana, and joins the Missouri River just beyond the Montana-North Dakota line. The City of Billings is a major metropolitan area located on the Yellowstone River, which has three major tributaries, viz., Bighorn River, Tongue River, and Powder River. Shoshone River is a tributary stream to Bighorn River. Two mountain ranges cross the Yellowstone River Basin. These are the Absaroka Range and Bighorn Mountains. Yellowstone National Park is a major recreational area.

The Yellowstone River main-stem drainage basin has a total land area of 27,263 miles^2, of which only 11% is cropland, and only 5% is harvested cropland. It has 692,250 cattle, 35,800 hogs, and 188,250 chickens, the density of livestock being 34/mile^2. Fertilizer application rate averages only about 1.3 tons/mile^2/year.

Figure 19 shows the changes in DO, BOD, and NO_3 concentrations in the river at various stations located along the path of the river. In the graph, the variation of flowrate at these stations is also shown. Although some stations do not contain sufficient data for water quality parameters shown, it is clear that the concentration levels for NO_3 and BOD are very low, and DO levels quite high, indicating a relatively high quality stream. The turbidity levels are also very low (often less than 100 JU). Thus, the relatively low levels of land uses appear to produce little degradation in stream water quality.

Bighorn River

Bighorn River is a tributary to Yellowstone River. The water quality in Bighorn River is also generally good as indicated by DO and NO_3 (Figure 20). The BOD concentration for one station indicates an unusually high value (90.8 mg/liter), which is not explained by other water quality data. Land uses in the drainage basin include an extremely low level of cropland (5.7%), about 20 livestock/mile^2, and about 1.5 tons of fertilizer used per square mile. These values are similar to those of the Yellowstone River Basin.

Belle Fourche River

A tributary to the Cheyenne River, which joins the Missouri River through Lake Oahe in the central plains of South Dakota, Belle Fourche River flows through Wyoming and South Dakota. Less than 10% of the land draining into Belle Fourche River is cropland, and relatively low density livestock operations prevail in the basin. Livestock data for 1969 show that there are 130,940 cattle, 4,360 hogs, and 17,910 chickens among other livestock, with an average density in excess of 26/mile^2. There is a progressive increase in the use of commercial fertilizer in the basin in the downstream direction, with an average application rate of nitrogen and phosphate fertilizer of about 0.3 tons/mile /year.

Figure 21 shows the distribution profile of NO_3, BOD, and DO concentrations in milligrams per liter, and flowrates, in CFS, at various stations on the river. Although data are limited for BOD and DO, the rapid increase in nitrate concentration, particularly below the town of Belle Fourche, indicates deterioration of water quality in the stream. This increase of pollutant concentration, in spite of increased flowrate, suggests that the possible sources of pollution are feedlots near the stream.

White River

The White River is a tributary of the Missouri River, originating in the Pine Ridge Range of northwest Nebraska and flowing through the south central plains of South Dakota. The drainage basin is essentially rural and is sparsely populated. Its dedication to agriculture is reflected by the farmland (nearly all of the total land) and cropland (about 20% of the total land), and in its livestock operations, with 341,000 cattle, 53,300 hogs, and 61,000 chickens on an area of only 9,340 miles^2. This represents a livestock density of over 50/mile^2. The use of commercial fertilizer is about 0.5 tons/mile^2/year.

A profile of concentrations of NO_3, BOD, and DO, in milligrams per liter at various water quality monitoring stations is presented graphically in Figure 22, which also shows the flowrate at these stations. The graph indicates that both BOD and NO_3 concentrations increase with a decline in DO concentration along the river. Thus, there is a gradual decline in water quality, due most probably to the high density of livestock in the basin.

Niobrara River

A tributary of the Missouri River, the Niobrara River flows mostly through the northern part of Nebraska, which is a very sparsely populated region. There are few major urban centers intercepting or draining into this river, but a relatively high density of livestock (75/mile^2) exists in the basin. A high proportion of land use is related to cropland (20%) and the overall commercial fertilizer application rate is moderate (2.1 tons/mile^2/year). In spite of intensive agricultural operations in this river basin, there appears to be relatively little degradation of water quality, as reflected by DO concentration in Figure 23. Nitrate data are not available to assess the effect of fertilizer application, but there appears to be an increase in BOD concentration in the stream from the data for BOD at Station No. 4100016 (3.25 mg/liter).

Big Sioux River

This river, a tributary of the Missouri River, flows southerly through South Dakota and Nebraska, with its confluence near Sioux City. Sioux Falls, Brookings, and Watertown are major cities on the river. The river basin is urbanized with many small towns and villages scattered in the basin. Its land use pattern is predominantly agricultural, with high concentrations of livestock and crop production. The proportion of cropland is about 80%, most of which is devoted to harvested cropland. The number of cattle, hogs, and chickens produced in the basin is high; cattle, 852,000; hogs, 85,000; and chickens, 1,450,000; with the average density of livestock being about 404/mile^2. The use of commercial fertilizer is also quite high, averaging about 11 tons of nitrogen and phosphate fertilizer per square mile per year. The use of herbicides and insecticides in the basin is also higher than the average values for the entire Missouri Basin.

The water quality changes in the river are presented graphically in Figure 24. The graphs show rapid increases in nitrate and BOD, and a decrease of DO in the river. The water quality degradation in the stream is consistent with the high use of fertilizers, crop harvesting, and feedlot operations in the Basin.

North Platte River

The Platte River Basin comprises a large drainage area in three states of Wyoming, Colorado, and Nebraska, with several streams joining the Platte River, which is a major tributary of the Missouri River. Among these streams, the North Platte is the longest, originating in the Rocky Mountains in northern Colorado and flowing northerly in Wyoming in the foothills of Medicine Bow Mountains, easterly along the foothills of the Laramie Mountains and in the great plains in Nebraska, and finally joining the Platte River near North Platte, Nebraska. The drainage basin is well populated, but the predominant land use is agriculture. However, the intensity of agricultural use is relatively low: cropland (less than 10%); livestock (427,000 cattle, 21,500 hogs, 24,600 chickens); density of livestock (32.1/mile^2). The use of commercial fertilizer is also moderate (2.2 tons/mile^2/year).

Figure 25 shows water quality in the North Platte River at various stations. The NO_3 and BOD concentrations appear to be low, while DO concentration is relatively high, indicating that the stream water quality is generally satisfactory.

South Platte River

The South Platte River also originates in the Rocky Mountains, passing through Colorado and Nebraska, before joining the Platte River near the City of North Platte. The major metropolitan area located on the South Platte River is Denver, Colorado; several other towns are scattered along the river.

The drainage basin is primarily agricultural, with cropland (32%) and livestock operations (105/mile^2) dominating its land use. There is also a relatively high rate of commercial fertilizer use in the basin (5.5 tons/mile^2/year).

These land use characteristics are reflected in the water quality changes in the stream, as shown in Figure 26. BOD values are usually high in the middle segment of the river, while nitrate concentration is shown to be increasing. Thus, the general water quality of the stream appears to be on the decrease.

Platte River

The Platte River, a tributary to the Missouri River, flows through the central plains of Nebraska and joins the Missouri River at Plattesmouth, Nebraska. From North Platte to Plattesmouth, the Platte River is about 340 miles in length and becomes increasingly urbanized as it progresses towards its confluence with the Missouri River.

The Platte River Basin has one of the most intensive agricultural land uses found anywhere in the Basin. It has about 65% of total land under cultivation for crops, corn being the largest harvested crop. There are more than 776,000 cattle, 493,000 hogs, and 636,000 chickens in the six watersheds covering the Platte River Basin, with a livestock density of more than 300/mile^2. Commercial fertilizer use is also one of the most intensive: 142,785 tons of nitrogen fertilizer and 38,041 tons of phosphate fertilizer or about 30 tons of fertilizer (nitrogen and phosphate) per square mile per year. The area is also characterized by a high application of herbicides (1,422 tons) and insecticides (750 tons) with an annual average rate of insecticide application at about 0.35 tons/mile^2.

These intensive land uses are reflected in the water quality changes at various stations in the Platte River. Figure 27 shows BOD, NO_3, and DO concentration profiles at various stations, along with the flowrate of the stream. BOD concentration has a pronounced upward slope along the downstream direction, while DO concentration is shown to be decreasing. However, NO_3 concentration does not appear to be increasing in the Platte River, although in the Missouri, NO_3 as well as BOD concentrations are rapidly increasing. Thus, from a water quality point of view, there is a high correlation between land use, increased concentration of biodegradable pollutants, and decreased DO concentration in the river.

Republican River

The Republican River is a tributary to the Kansas River, which joins the Missouri River at Kansas City. The Republican River originates in eastern Colorado and flows mostly through southern Nebraska before joining the Kansas River near Junction City, Kansas, through Milford Reservoir.

The total area of the watershed draining into the Republican River upstream of Orleans, Nebraska, is 12,383 miles^2, of which more than 50% is cropland. There are more than 761,000 cattle, nearly 300,000 hogs, and 320,000 chickens in the basin. The total livestock density thus averages over 111/mile^2. The use of commercial fertilizer is also quite intensive, averaging about 11 tons of nitrogen and phosphate fertilizer per square mile of the Basin. The use of herbicide and insecticide chemicals amounts to about 0.15 tons/mile^2/year. Thus, the potential water pollution problems for intensive agricultural land uses in the basin are significant.

Figure 28 shows water quality changes in the river basin at various monitoring stations, in terms of DO, NO_3, and BOD. In this figure, flowrates are also represented.

The variations of BOD and NO_3 concentrations show very little upward trend, while the DO concentration appears to fluctuate significantly, dropping from a high value of 10.3 near Trenton, Nebraska, to a low value of 8.3 near McCook, Nebraska. The flowrate increases gradually in the downstream direction in the river, increasing rapidly beyond the City of McCook. This increase of flowrate may have resulted in the dilution of pollutants and prevented elevated concentrations of pollutants in the river.

Thus, water quality in the Republican River does not appear to reflect the intense agricultural operations in the river basin, presumably because the river has a high capacity to assimilate pollutants.

REGRESSION ANALYSIS

Statistical techniques were used to determine the degree of association between variables and the functional relationships between the variables. If X and Y are both random variables which follow some unknown bivariate distribution, the degree of association between the two variables in the distribution pattern is explained by a correlation coefficient between X and Y within a given sample space. Regression analysis establishes the dependency relationship that may exist between X and Y. In a linear regression analysis, the observed values of Y for given values of X are fitted to a straight line, using the method of least squares, on an X-Y plane. Here Y is a dependent variable, while X is an independent variable, i.e., X is a random variable which determines the changes in Y. Thus, from a regression equation, one can predict the size of the change in Y when a unit change is made in X.

When more than two variables are involved, the same regression technique can be applied on an n-dimensional space, when n corresponds to the number of variables. When the random variables are selected one at a time in multiple regression analysis, the method is called stepwise regression.

Both bivariate and multivariate regression analyses were performed on the data. The parameters which were assumed to be random and thus "independent" variables were land use parameters, soil, and climatic factors. The dependent variables were assumed to be the parameters of water quality, since the various land use activities of man, and natural geophysical factors, cause changes in water quality in streams.

Bivariate Regression Analysis

Basically, bivariate regression analyses have been made between water quality parameters, including DO (dissolved oxygen), turbidity, BOD (biochemical oxygen demand), P (phosphate), NO_3 (nitrate), and DS (dissolved solids); and land use parameters, including cattle, hogs, cattle and hogs, livestock (cattle + hogs + sheep + chickens) (livestock populations were expressed in units of animal waste generation, with a beef animal as the unit reference point), nitrogen fertilizer, phosphate fertilizer, and total fertilizer (nitrogen + phosphate) (in tons per year), cropland (square miles) and irrigated land (square miles). For water quality parameters, we have used two types of measurement. One is the pollutant load (e.g., pounds per day per square mile, obtained by multiplying stream flow with pollutant concentration and dividing by watershed area). The second type of measurement is the concentration in milligrams per liter. Land use parameters have been converted to a unit area base, e.g., tons of N fertilizer per square mile of watershed.

In the subsequent analysis of water pollution due to livestock, it was found necessary to express livestock populations in terms of an equivalent population, preferably cattle, as cattle wastes represent the largest livestock wastes in the basin. The weights assigned were found to be dependent on the specific pollutants being analyzed. Thus, three sets of weights were chosen for three pollutants, viz., BOD, nitrogen as N, and phosphorus as P_2O_5.

The relative weights assigned to the wastes from cattle, hogs, sheep, and chickens were computed from the literature, and are shown in Table 6.

Tables 7 through 10 show correlation coefficients of regressions between selected water quality parameters and land use variables for all subbasins in the Missouri Basin. Table 7 shows linear regression analysis for pollutant mass flowrate (lb/day) per square mile of watershed as a function of each of the land use parameters per square mile of watershed. The regression equation is of the form $Y = A + BX$. Table 9 shows results of regression analyses performed on data transformed into natural logarithms of the same variables as in Table 7. The regression equation is of the form $\ell nY = A + B\,\ell nX$.

Similar analyses were performed with water quality parameters (mg/liter) and land use parameters per square mile of watershed both in normal units and in natural logarithms, and are shown in Tables 8 and 10.

Table 6. POLLUTANT POTENTIAL OF VARIOUS FARM ANIMALS[a/]

Animal	BOD_5 lb/animal/day	BOD ratio[b/]	Nitrogen lb/animal/day	N ratio[b/]	P_2O_5 lb/animal/day	P_2O_5 ratio[b/]	N/P
Cattle	1.0 - 1.5 (1.0)	1.0	0.26 - 0.49 (0.40)	1.0	0.12	1.0	15.30
Hogs	0.2 - 0.56 (0.25)	0.25	0.032 - 0.05 (0.036)	0.09	0.025	0.21	6.58
Sheep	0.05 - 0.15 (0.10)	0.10	0.02 - 0.03 (0.025)	0.063	0.012	0.10	9.56
Chickens	0.015	0.015	0.003 - 0.0036 (0.0033)	0.0067	0.0026	0.022	5.80

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a/ Data compiled from Loehr[1/], Klausner et al.[2/], and MRI[3/].

b/ This ratio is standardized with respect to cattle (1.0). Thus, the BOD of waste from one chicken is 0.015 times the BOD of waste produced by one beef animal.

1/ Loehr, R. C., Pollution Implications of Animal Wastes: A Forward Oriented Review, FWPCA-WRC, Ada, Oklahoma (1968).

2/ Klausner, S. D., P. J. Zwerman, and T. W. Scott, Land Disposal of Manure in Relation to Water Quality, in Agricultural Wastes, Cornell Conference (1971).

3/ MRI, "The Pollution Potential of the Confined Livestock Feeding Industry," Final Report, EPA Contract No. 68-01-0025, November 1971.

Table 7.

Pollutant Loading Versus Land Use: Linear Regression Analysis

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL	N	[illegible]	MEAN	NO.	STANDARD DEVIATION	Y = A + BX A	B	REGRESSION SIGNIFICANCE
[illegible]						[illegible]	34	[illegible]			
	CAT/SQ MI	[illegible]	.142	34	1, 32	62.469	233	46.413	[illegible]	[illegible]	.76044
	HOUS/SQ MI	[illegible]	.148	34	1, 32	38.211	233	52.358	[illegible]	[illegible]	.73802
	LVSTK/SQMI	[illegible]	.194	34	1, 32	[illegible]	233	[illegible]	[illegible]	[illegible]	.83595
	NITRO/SQMI	[illegible]	[illegible]	34	1, 32	7.044	233	9.157	[illegible]	[illegible]	8.87038
	PHOS/SQ MI	[illegible]	[illegible]	34	1, 32	[illegible]	228	[illegible]	[illegible]	[illegible]	2.79544
	CROP/SQ MI	[illegible]	[illegible]	34	1, 32	[illegible]	233	.284	[illegible]	[illegible]	4.48521
	IRRI/SQ MI	[illegible]	.381	31	1, 29	[illegible]	201	.053	[illegible]	[illegible]	.09401
	RAINFALL	[illegible]	[illegible]	34	1, 32	22.244	233	4.170	[illegible]	[illegible]	14.88311
[illegible]						[illegible]	6	[illegible]			
	CAT/SQ MI	[illegible]	[illegible]	6	1, 4	[illegible]	233	46.413	[illegible]	.19503	.88381
	HOUS/SQ MI	[illegible]	[illegible]	6	1, 4	38.211	233	52.358	[illegible]	[illegible]	3.30905
	LVSTK/SQMI	[illegible]	[illegible]	6	1, 4	[illegible]	233	[illegible]	[illegible]	.17818	1.04744
	NITRO/SQMI	[illegible]	[illegible]	6	1, 4	[illegible]	233	9.157	[illegible]	[illegible]	2.75238
	PHOS/SQ MI	[illegible]	[illegible]	6	1, 4	[illegible]	228	[illegible]	[illegible]	[illegible]	4.93063
	CROP/SQ MI	[illegible]	[illegible]	6	1, 4	[illegible]	233	[illegible]	[illegible]	[illegible]	1.03281
	IRRI/SQ MI	[illegible]	[illegible]	6	1, 4	[illegible]	201	[illegible]	[illegible]	[illegible]	.14251
	RAINFALL	[illegible]	[illegible]	6	1, 4	[illegible]	233	[illegible]	[illegible]	1.81998	4.80282
[illegible]						[illegible]	134	[illegible]			
	CAT/SQ MI	[illegible]	[illegible]	134	1,132	[illegible]	233	[illegible]	-8.01842	[illegible]	11.55900
	HOUS/SQ MI	[illegible]	[illegible]	134	1,132	38.211	233	52.358	[illegible]	[illegible]	21.44035
	LVSTK/SQMI	[illegible]	[illegible]	134	1,132	[illegible]	233	[illegible]	[illegible]	[illegible]	13.01200
	NITRO/SQMI	[illegible]	[illegible]	134	1,132	[illegible]	233	9.157	[illegible]	.40392	1.38360
	PHOS/SQ MI	[illegible]	.002	134	1,132	[illegible]	228	[illegible]	[illegible]	5.82721	8.73598
	CROP/SQ MI	[illegible]	[illegible]	134	1,132	[illegible]	233	.284	[illegible]	[illegible]	7.92088
	IRRI/SQ MI	[illegible]	[illegible]	121	1,119	[illegible]	201	.053	[illegible]	-55.35155	[illegible]
	RAINFALL	[illegible]	[illegible]	134	1,132	[illegible]	233	4.170	[illegible]	[illegible]	[illegible]
OS-PHO/M2						[illegible]	139	[illegible]			
	CAT/SQ MI	[illegible]	[illegible]	139	1,137	[illegible]	233	[illegible]	[illegible]	.00511	1.2514
	HOUS/SQ MI	[illegible]	[illegible]	139	1,137	[illegible]	233	52.358	[illegible]	.00393	.93995
	LVSTK/SQMI	[illegible]	[illegible]	139	1,137	[illegible]	233	[illegible]	[illegible]	.00465	1.23728
	NITRO/SQMI	[illegible]	[illegible]	139	1,137	[illegible]	233	9.157	1.08565	.00382	[illegible]
	PHOS/SQ MI	[illegible]	[illegible]	139	1,137	[illegible]	228	[illegible]	[illegible]	.11656	2.68638
	CROP/SQ MI	[illegible]	[illegible]	139	1,137	[illegible]	233	[illegible]	[illegible]	[illegible]	.69303
	IRRI/SQ MI	[illegible]	[illegible]	125	1,123	[illegible]	201	[illegible]	[illegible]	[illegible]	.58770
	RAINFALL	[illegible]	[illegible]	139	1,137	[illegible]	233	[illegible]	[illegible]	[illegible]	3.05860
TUR/M2						[illegible]	89	[illegible]			
	CAT/SQ MI	[illegible]	[illegible]	89	1, 87	[illegible]	233	[illegible]	[illegible]	[illegible]	20.66560
	HOUS/SQ MI	[illegible]	[illegible]	89	1, 87	38.211	233	[illegible]	[illegible]	[illegible]	[illegible]
	LVSTK/SQMI	[illegible]	[illegible]	89	1, 87	[illegible]	233	[illegible]	[illegible]	[illegible]	[illegible]
	NITRO/SQMI	[illegible]	[illegible]	89	1, 87	[illegible]	233	[illegible]	[illegible]	[illegible]	[illegible]
	PHOS/SQ MI	[illegible]	[illegible]	85	1, 83	[illegible]	228	[illegible]	[illegible]	[illegible]	[illegible]
	CROP/SQ MI	[illegible]	[illegible]	89	1, 87	[illegible]	233	[illegible]	[illegible]	[illegible]	4.12137
	IRRI/SQ MI	[illegible]	[illegible]	78	1, 76	[illegible]	201	[illegible]	[illegible]	[illegible]	[illegible]
	RAINFALL	[illegible]	[illegible]	89	1, 87	[illegible]	233	4.170	[illegible]	[illegible]	[illegible]
[illegible]											
	CAT/SQ MI	[illegible]	[illegible]	55	1, 53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	HOUS/SQ MI	[illegible]	[illegible]	55	1, 53	[illegible]	233	[illegible]	[illegible]	[illegible]	[illegible]
	LVSTK/SQMI	[illegible]	[illegible]	55	1, 53	[illegible]	233	[illegible]	[illegible]	[illegible]	1.71141
	NITRO/SQMI	[illegible]	[illegible]	55	1, 53	[illegible]	233	[illegible]	[illegible]	[illegible]	[illegible]
	PHOS/SQ MI	[illegible]	[illegible]	55	1, 53	[illegible]	228	[illegible]	[illegible]	[illegible]	[illegible]
	CROP/SQ MI	[illegible]	[illegible]	55	1, 53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	IRRI/SQ MI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	201	[illegible]	[illegible]	[illegible]	[illegible]
	RAINFALL	[illegible]	[illegible]	55	1, 53	[illegible]	233	[illegible]	[illegible]	[illegible]	[illegible]

Table 8.

Water Quality Versus Land Use: Linear Regression Analysis

DEPENDENT VARIABLE Y	INDEPENDENT VARIABLE X	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL	NO. OF (X,Y) PAIRS N	MEAN	NO. OF OBS.	STANDARD DEVIATION	REGRESSION EQUATION Y = A + BX A	 B	REGRESSION SIGNIFICANCE F
DO-MGL					8.559	98	1.762			
	CATTLE	.0051	.480	98	62.869	233	46.413	8.55672	.00019	.00200
	HOGS	.0441	.415	98	34.211	233	52.358	8.61210	.00165	.18631
	COWS+HOGS	.0305	.383	98	97.080	233	95.144	8.61407	.00056	.07160
	LIVESTOCK	-.0511	.308	98	160.073	233	162.256	8.75781	-.00656	.20197
	NITROGEN	.0580	.285	98	7.084	233	9.157	8.58981	.01116	.25981
	PHOSPHATE	-.0325	.378	98	2.698	228	2.967	8.72092	-.01929	.04131
	FERTILIZER	.0554	.294	98	9.724	233	11.619	8.58721	.00840	.23682
	IRRIGATED	.0055	.481	79	.039	201	.053	8.66169	.18336	.00235
BOD-MGL					6.819	66	15.031			
	CATTLE	.2314	.031	66	62.869	233	46.413	2.10709	.07495	3.28216
	HOGS	.0960	.222	66	34.211	233	52.358	5.87658	.02755	.53920
	COWS+HOGS	.1615	.098	66	97.080	233	95.144	6.36251	.02551	1.55290
	LIVESTOCK	.3991	.000	66	160.073	233	162.256	.90121	.03697	10.98703
	NITROGEN	.2646	.016	66	7.084	233	9.157	3.76173	.43662	4.36812
	PHOSPHATE	.1589	.111	61	2.698	228	2.967	4.64729	.80509	1.50270
	FERTILIZER	.2469	.023	66	9.724	233	11.619	3.71312	.31942	3.76561
	IRRIGATED	-.0977	.253	60	.039	201	.053	7.73242	-26.93065	.44967
P-MGL					1.149	13	2.069			
	CATTLE	.3733	.109	13	62.869	233	46.413	.13337	.01648	1.13359
	HOGS	.0624	.420	13	34.211	233	52.358	1.08589	.00244	.02739
	COWS+HOGS	.2144	.220	13	97.080	233	95.144	.67949	.00505	.40704
	LIVESTOCK	.1765	.282	13	160.073	233	162.256	.81267	.00223	.22512
	NITROGEN	.1677	.270	13	7.084	233	9.157	.87203	.04199	.25569
	PHOSPHATE	.1116	.354	13	2.698	228	2.967	.96166	.07703	.08822
	FERTILIZER	.1721	.287	13	9.724	233	11.619	.87632	.03035	.21373
	IRRIGATED	-.1823	.319	9	.039	201	.053	1.44516	-7.03666	.24050
NO3-MGL					2.672	135	3.411			
	CATTLE	.4136	.000	135	62.869	233	46.413	.76047	.03040	24.55719
	HOGS	.2436	.000	135	34.211	233	52.358	2.01766	.01913	11.22483
	COWS+HOGS	.3672	.000	135	97.080	233	95.144	1.39601	.01316	18.54495
	LIVESTOCK	.2425	.000	135	160.073	233	162.256	1.68776	.00615	11.13231
	NITROGEN	.4085	.000	135	7.084	233	9.157	1.59399	.15218	23.83760
	PHOSPHATE	.3290	.000	135	2.698	228	2.967	1.65150	.37825	14.44848
	FERTILIZER	.4060	.000	135	9.724	233	11.619	1.51312	.11918	9.48172
	IRRIGATED	.3445	.000	121	.039	201	.053	1.80637	22.14512	16.02576
DS-TPD					1603.262	139	7312.678			
	CATTLE	.0350	.341	139	62.869	233	46.413	1256.39213	5.51732	.15101
	HOGS	.0827	.167	139	34.211	233	52.358	1208.33088	11.54397	.84607
	COWS+HOGS	.0620	.234	139	97.080	233	95.144	1140.50848	4.76671	.47492
	LIVESTOCK	.0524	.270	139	160.073	233	162.256	1225.60304	2.35930	.33799
	NITROGEN	.0138	.436	139	7.084	233	9.157	1525.31836	11.00281	.02335
	PHOSPHATE	.1067	.110	139	2.698	228	2.967	906.93869	258.08764	1.36691
	FERTILIZER	.0371	.332	139	9.724	233	11.619	1376.45594	23.32408	.16917
	IRRIGATED	-.0861	.170	125	.039	201	.053	2068.38667	1871.35614	.91965
TURBIDITY					327.590	89	852.669			
	PHOSPHATE	.2251	.019	85	2.698	228	2.967	152.57611	64.68252	4.05650
	RAINFALL	-.0195	.428	89	22.[illegible]	233	9.170	367.36609	-1.81051	.02883
	CATTLE	.3685	.000	89	62.869	233	46.413	-75.[illegible]7127	6.40315	10.50902
	HOGS	.2459	.010	89	34.211	233	52.358	190.0[illegible]408	4.00503	4.89244
	CROPLAND	.2291	.015	89	.610	233	.289	50.26560	674.89656	4.20828
	IRRIGATED	-.0180	.438	78	.039	201	.053	338.44485	-289.90159	.02475

Table 9.

Pollutant Loading Versus Land Use: Logarithmic Regression Analysis

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	CORRELATION COEFFICIENT (R)	SIGNIFICANCE LEVEL		NO. OF	MEAN	OBS.	STANDARD DEVIATION	REGRESSION EQUATION LN(Y)=A+B*LN(X)		REGRESSION SIGNIFICANCE
Y	X			N	DF				A	B	F
BOD-KPD/M2						[illegible]	34	1.883			
	CAT/SQ MI	.3007	.042	34	1, 32	3.853	233	.805	-.40576	.70364	3.18201
	HOGS/SQ MI	.3860	.012	34	1, 32	1.967	233	2.223	1.66265	.32695	5.60329
	LVSTK/SQMI	.3313	.028	34	1, 32	3.911	233	.806	-.75971	.76699	3.94614
	NITRO/SQMI	.5581	.000	34	1, 32	.874	233	1.731	1.77561	.50690	14.47658
	PHOS/SQ MI	.5651	.000	34	1, 32	.102	228	1.663	2.23466	.64760	15.01386
	CROP/SQ MI	.3332	.027	34	1, 32	-1.370	233	1.186	3.03027	.52888	3.99727
	IRRI/SQ MI	-.0881	.319	31	1, 29	-4.028	201	1.419	1.43479	-.11691	.22681
	RAINFALL	.4158	.007	34	1, 32	3.017	233	.417	-3.35566	1.87629	6.68877
P-KPD/M2						[illegible]	6	1.857			
	CAT/SQ MI	.5524	.128	6	1, 4	3.853	233	.805	-3.79714	1.27489	1.75636
	HOGS/SQ MI	.4912	.161	6	1, 4	1.967	233	2.223	.30840	.41063	1.27217
	LVSTK/SQMI	.5542	.127	6	1, 4	3.911	233	.806	-3.82171	1.25383	1.77303
	NITRO/SQMI	.5551	.126	6	1, 4	.874	233	1.731	.59532	.59567	1.78135
	PHOS/SQ MI	.5971	.106	6	1, 4	.102	228	1.663	1.04678	.67505	2.21620
	CROP/SQ MI	.3708	.235	6	1, 4	-1.370	233	1.186	1.91096	.58053	.63760
	IRRI/SQ MI	-.1863	.362	6	1, 4	-4.028	201	1.419	.11335	-.24386	.14378
	RAINFALL	.5424	.134	6	1, 4	3.017	233	.417	-6.13826	2.40417	1.66727
NO3-KPD/M2						.747	134	2.459			
	CAT/SQ MI	.5063	.000	134	1,132	3.853	233	.805	-5.21433	1.54708	45.49325
	HOGS/SQ MI	.4876	.000	134	1,132	1.967	233	2.223	-.31357	.53940	41.17199
	LVSTK/SQMI	.5165	.000	134	1,132	3.911	233	.806	-5.16678	1.54708	48.01685
	NITRO/SQMI	.5186	.000	134	1,132	.874	233	1.731	.10389	.73639	48.52596
	PHOS/SQ MI	.5386	.000	134	1,132	.102	228	1.663	.66509	.80617	53.94283
	CROP/SQ MI	.3610	.000	134	1,132	-1.370	233	1.186	1.77265	.74461	19.78688
	IRRI/SQ MI	.1191	.097	121	1,119	-4.028	201	1.419	1.57903	.20669	1.71311
	RAINFALL	.4444	.000	134	1,132	3.017	233	.417	-7.15668	2.61898	32.47797
DS-TPD/M2						[illegible]	139	1.702			
	CAT/SQ MI	.1231	.074	139	1,137	3.853	233	.805	-2.17481	.26024	2.10679
	HOGS/SQ MI	.1057	.108	139	1,137	1.967	233	2.223	-1.33610	.08091	1.54756
	LVSTK/SQMI	.1295	.064	139	1,137	3.911	233	.806	-2.24882	.27405	2.33767
	NITRO/SQMI	.0950	.133	139	1,137	.874	233	1.731	-1.25856	.09335	1.24711
	PHOS/SQ MI	.1962	.010	139	1,137	.102	228	1.663	-1.19770	.20318	5.48293
	CROP/SQ MI	-.0287	.365	139	1,137	-1.370	233	1.186	-1.23335	-.04115	.11286
	IRRI/SQ MI	-.0482	.297	125	1,123	-4.028	201	1.419	-1.40966	-.05776	.28591
	RAINFALL	.0729	.197	139	1,137	3.017	233	.417	-2.07350	.24714	.73104
TUR/M						[illegible]	89	2.015			
	CAT/SQ MI	.2183	.020	89	1, 87	3.853	233	.805	-4.83214	.54662	4.35384
	HOGS/SQ MI	.2455	.010	89	1, 87	1.967	233	2.223	-3.16340	.22252	5.57932
	LVSTK/SQMI	.2240	.017	89	1, 87	3.911	233	.806	-4.42006	.56103	4.59384
	NITRO/SQMI	.1968	.032	89	1, 87	.874	233	1.731	-2.42587	.22902	3.50499
	PHOS/SQ MI	.1824	.047	85	1, 83	.102	228	1.663	-2.74858	.22371	2.85688
	CROP/SQ MI	.1877	.039	89	1, 87	-1.370	233	1.186	-2.28900	.31880	3.17681
	IRRI/SQ MI	.0352	.380	78	1, 76	-4.028	201	1.419	-2.52456	.04995	.09413
	RAINFALL	.1815	.044	89	1, 87	3.017	233	.417	-5.37104	.87673	2.96523
OG-KPD/M2						[illegible]	55	1.421			
	CAT/SQ MI	.1730	.103	55	1, 53	3.853	233	.805	1.61510	.39148	1.63590
	HOGS/SQ MI	[illegible]	[illegible]	55	1, 53	1.967	233	2.223	[illegible]	.15597	1.99658
	LVSTK/SQMI	[illegible]	[illegible]	55	1, 53	3.911	233	.806	[illegible]	.41376	1.83189
	NITRO/SQMI	.2766	.020	55	1, 53	.874	233	1.731	2.86057	.29081	4.38923
	PHOS/SQ MI	.2843	.018	55	1, 53	.102	228	1.663	3.07241	.41527	4.65952
	CROP/SQ MI	.0879	.262	55	1, 53	-1.370	233	1.186	3.29461	.13466	.41266
	IRRI/SQ MI	-.0865	.295	41	1, 39	-4.028	201	1.419	2.66780	-.11047	.29386
	RAINFALL	.1152	.201	55	1, 53	3.017	233	.417	1.59785	.54272	.7129

Table 10.

Water Quality Versus Land Use: Logarithmic Regression Analysis

DEPENDENT VARIABLE (UNIT)	INDEPENDENT VARIABLE (UNIT)	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL	NO. OF OBSERVATIONS N	MEAN	NO. OF OBS.	STANDARD DEVIATION	REGRESSION COEFFICIENTS A	B	REGRESSION SIGNIFICANCE F
PO4-MG/L					[illegible]	98	.741			
	CATTLE	.0888	.250	98	3.8[illegible]	233	.805	2.26[illegible]	.0[illegible]	.36777
	HOGS	.0826	.209	98	1.9[illegible]	233	2.223	2.11[illegible]	.00[illegible]8	.52898
	COWS+HOGS	.0[illegible]10	.244	98	4.11[illegible]	233	1.008	2.06[illegible]	.01699	.34028
	LIVESTOCK	-.0[illegible]61	.39[illegible]	98	4.5[illegible]	233	.935	2.16[illegible]	-.00[illegible]26	.06084
	NITROGEN	.0117	.454	98	.874	233	1.731	2.13[illegible]	.00163	.01056
	PHOSPHATE	-.0808	[illegible]	98	.1[illegible]	228	1.663	2.13[illegible]	-.0[illegible]595	.12682
	FERTILIZER	.0[illegible]97	[illegible]	94	1.2[illegible]	233	1.671	2.12[illegible]	.0[illegible]573	.12140
	IRRIGATE	-.0[illegible]92	.3[illegible]	7[illegible]	-4.[illegible]	201	1.419	2.[illegible]388	-.01307	.27107
[illegible]-MG/L					[illegible]	66	.814			
	CATTLE	.3825	.001	66	3.8[illegible]	233	.805	-.12657	.38883	9.93764
	HOGS	.4114	.000	66	1.9[illegible]	233	2.223	1.06756	.15078	11.84615
	COWS+HOGS	.3888	[illegible]	66	4.11[illegible]	233	1.008	.05288	.31888	10.71177
	LIVESTOCK	.5028	[illegible]	66	4.5[illegible]	233	.935	-.74599	.45686	21.77300
	NITROGEN	.3252	.004	66	.874	233	1.731	1.23[illegible]	.15290	6.86098
	PHOSPHATE	.2771	.015	61	.1[illegible]	228	1.663	1.35009	.13725	4.82205
	FERTILIZER	.3006	.007	66	1.2[illegible]	233	1.671	1.17[illegible]	.14657	5.77089
	IRRIGATE	-.1[illegible]	.215	[illegible]	-4.[illegible]	201	1.419	1.1[illegible]415	.05[illegible]57	.83209
P-MG/L					-1.1[illegible]	13	1.881			
	CATTLE	.[illegible]889	.107	13	3.8[illegible]	233	.805	-4.0[illegible]474	.76145	1.10242
	HOGS	.3123	.144	13	1.9[illegible]	233	2.223	-1.58857	.23339	.75656
	COWS+HOGS	.3684	.117	13	4.11[illegible]	233	1.008	-3.53088	.58489	1.00860
	LIVESTOCK	.2[illegible]	.188	13	4.5[illegible]	233	.935	-3.53432	.51922	.65350
	NITROGEN	.1427	.321	13	.874	233	1.731	-1.26519	.13693	.14552
	PHOSPHATE	-.[illegible]5	.431	13	.1[illegible]	228	1.663	-1.12003	-.05612	.02011
	FERTILIZER	.[illegible]1	.406	13	1.2[illegible]	233	1.671	-1.21888	.07276	.03766
	IRRIGATE	-.[illegible]	.[illegible]88	9	-4.[illegible]	201	1.419	-2.37437	-.31004	.52778
NO3-MG/L					.2[illegible]	134	1.343			
	CATTLE	.5897	.000	134	3.8[illegible]	233	.805	-3.36761	.95014	56.54736
	HOGS	.5204	.000	134	1.9[illegible]	233	2.223	-.32476	.31467	43.82003
	COWS+HOGS	.5604	.000	134	4.11[illegible]	233	1.008	-2.77763	.74685	54.01492
	LIVESTOCK	.5318	.000	134	4.5[illegible]	233	.935	-3.24972	.76381	46.47464
	NITROGEN	.5363	.00[illegible]	134	.874	233	1.731	-.08981	.41609	47.63410
	PHOSPHATE	.4454	.000	134	.1[illegible]	228	1.663	.25659	.36436	29.23469
	FERTILIZER	.5124	.000	134	1.2[illegible]	233	1.671	-.23488	.41206	42.01890
	IRRIGATE	.1285	.088	1[illegible]	-4.[illegible]	201	1.419	.76839	.11784	1.85632
DS-T[illegible]					[illegible]	139	1.803			
	CATTLE	-.0124	.443	139	3.8[illegible]	233	.805	5.93753	-.02771	.01883
	HOGS	-.0053	.476	139	1.9[illegible]	233	2.223	5.83921	-.00431	.00367
	COWS+HOGS	.0014	.441	139	4.1	233	1.008	5.81669	.00346	.00046
	LIVESTOCK	.0744	.142	139	4.5[illegible]	233	.935	5.16474	.14356	.68546
	NITROGEN	-.0378	.33[illegible]	139	.874	233	1.731	5.86511	-.03935	.17589
	PHOSPHATE	.0414	.14[illegible]	139	.1[illegible]	228	1. 63	5.42050	.10031	1.03649
	FERTILIZER	-.0007	.4[illegible]	139	1.2[illegible]	233	1.671	5.83166	-.00072	.00006
	IRRIGATE	-.0[illegible]85	.154	125	-4.[illegible]	201	1 .419	5.36751	-.11500	1.01574
TURBIDITY					[illegible]	89	1.708			
	[illegible]	.[illegible]	.244	8[illegible]	-[illegible].9[illegible]	228	2.059	4.80188	.06332	.44516
	[illegible]	.[illegible]	.177	8[illegible]	3.017	233	.417	3.13441	.40615	.75556
	[illegible]	.[illegible]	.1[illegible]	[illegible]	-3.113	233	1.366	4.774[illegible]	.13152	.84973
	[illegible]	.[illegible]	[illegible]	[illegible]	-4.9[illegible]	233	2.561	4.49328	.11570	2.35788
	CROPLAND	.[illegible]	.121	[illegible]	-4.3[illegible]	233	1.441	5.45118	.13032	1.21071
	IRRIGATE	-.[illegible]15	.104	7[illegible]	-11.[illegible]	221	1.[illegible]71	[illegible]	-.12919	1.55294

The independent variables (X) and dependent variables (Y) of Tables 7 through 10 are defined as follows:

Y, Dependent Variable

BOD --- Biochemical Oxygen Demand, lb/mile^2/day
P --- Phosphorus, lb/mile^2/day
NO_3 --- Nitrate, lb/mile^2/day
DS --- Dissolved Solids, tons/mile^2/day
Tur --- Turbidity, Jackson turbidity units/mile^2
DO --- Dissolved Oxygen, lb/mile^2/day

X, Independent Variable

CAT --- number of cattle/mile^2
HOGS --- number of hogs/mile^2
LVSTK --- number of livestock (as cattle)/mile^2
NITRO --- nitrogen fertilizer applied, tons/mile^2/year
PHOS --- phosphate fertilizer applied, tons/mile^2/year
CROP --- cropland, mile^2/mile^2 of basin
IRRI --- irrigated land, mile^2/mile^2 of basin
RAINFALL --- rainfall amount, in/year

A comparison of the regressions is made in terms of a statistical test (F-distribution) for the goodness of fit to assess the usefulness of the data base. Table 7 which is based on pollutant loading (lb/mile^2/day) shows 14 statistically significant linear regressions at 95% confidence level based on F-distribution. Table 8 which is based on concentration (mg/liter) of water quality parameters, also shows 14 significant linear regressions at the same level. The number of significant regressions in Table 9 and Table 10, which are based on logarithms of the same variables as in Tables 7 and 8, are, respectively, 17 and 14. Nitrate, BOD, and turbidity yielded the largest number of significant regressions. The results of Tables 7 through 10 may be summarized for the number of significant regressions for each water quality parameter as follows:

SUMMARY OF SIGNIFICANT REGRESSIONS

Table No.	BOD	P	NO_3	DS	DO	Turbidity	Total
7	3	0	6	0	0	5	14
8	2	0	8	0	0	4	14
9	4	0	7	1	2	3	17
10	7	0	7	0	0	0	14

There appears to be very little difference in total number of regressions when linear regressions are compared with logarithmic regressions. BOD, DO, and DS yielded more number of significant regressions while turbidity yielded less on a logarithmic scale. It appears that, in general, both linear and logarithmic regressions can yield equally significant regression equations to describe adequately the given data.

Figures 29 through 34 describe graphically some of the regression analyses shown in Tables 7 through 10. These plots are summarized as follows.

Figure No.	Regression Equation
29	BOD, mg/liter = 0.88 (cattle/mile^2)$^{0.39}$
30	BOD, lb/mile^2/day = 0.47 (livestock/mile^2)$^{0.77}$
31	BOD, lb/mile^2/day = -0.63 + 99.28 (cropland/mile^2)
32	NO_3, lb/mile^2/day = 0.006 (cattle/mile^2)$^{1.55}$
33	Turbidity, JU = -75.5 + 6.4 (cattle/mile^2)
34	NO_3, lb/mile^2/day = 0.90 (N applied/mile^2)$^{0.74}$

These regressions are significant at the 95% confidence level.

Multiple Regression Analysis

Critical examination of the results of bivariate regression analyses was made to determine significant functional relationships between water quality parameters and land use parameters. This examination revealed that these analyses could be used to determine the selection of independent variables to be subjected to stepwise multiple regression analyses.

Four water quality variables were chosen for the analysis as independent variables. These were: (a) turbidity (JU); (b) turbidity (JU) x flow rate (cu ft/sec)/mi^2; (c) BOD (lb/mile^2/day); and (d) nitrate (lb/mile^2/day). The results of bivariate regression analyses as shown in Tables 7 through 10 and summarized on page 64 show that the total number of significant regressions for BOD, NO_3, and turbidity was 16, 28, and 12 respectively. Other parameters had much fewer number of significant regressions. Therefore the multiple regression analysis was conducted for BOD, NO_3, and turbidity. Since turbidity was measured in Jackson turbidity units (JU) as concentration of suspended matter, it was decided arbitrarily to convert the concentration units to mass units by multiplying with the flow rate. However, no attempt was made to express these units in lb mass flow rates because of a lack of correlation between turbidity (JU) and mass concentration of suspended solids (mg/ℓ).

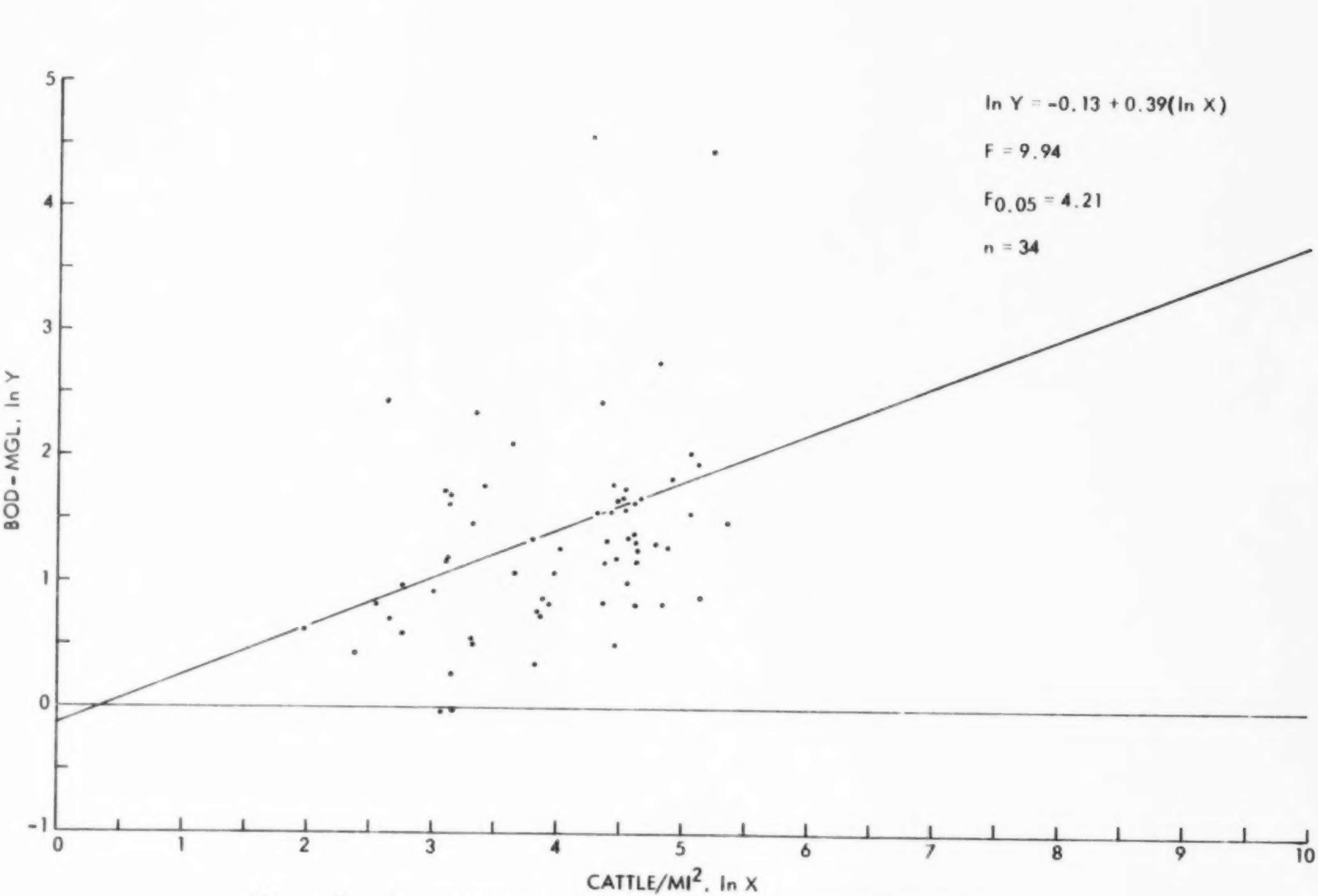

Figure 29. Regression of BOD-MGL versus cattle per square mile

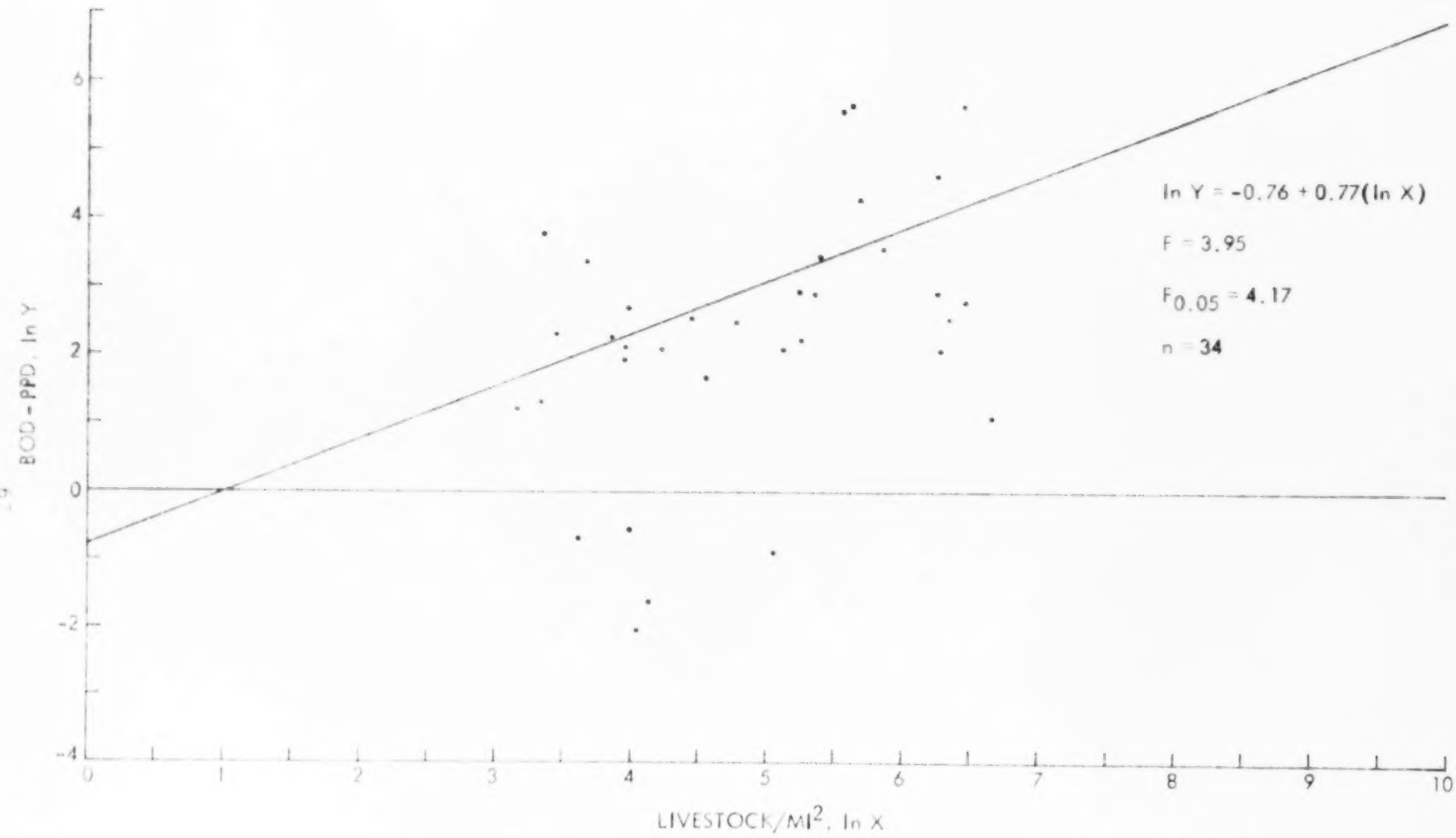

Figure 30. Regression of BOD-PPD per square mile versus livestock per square mile

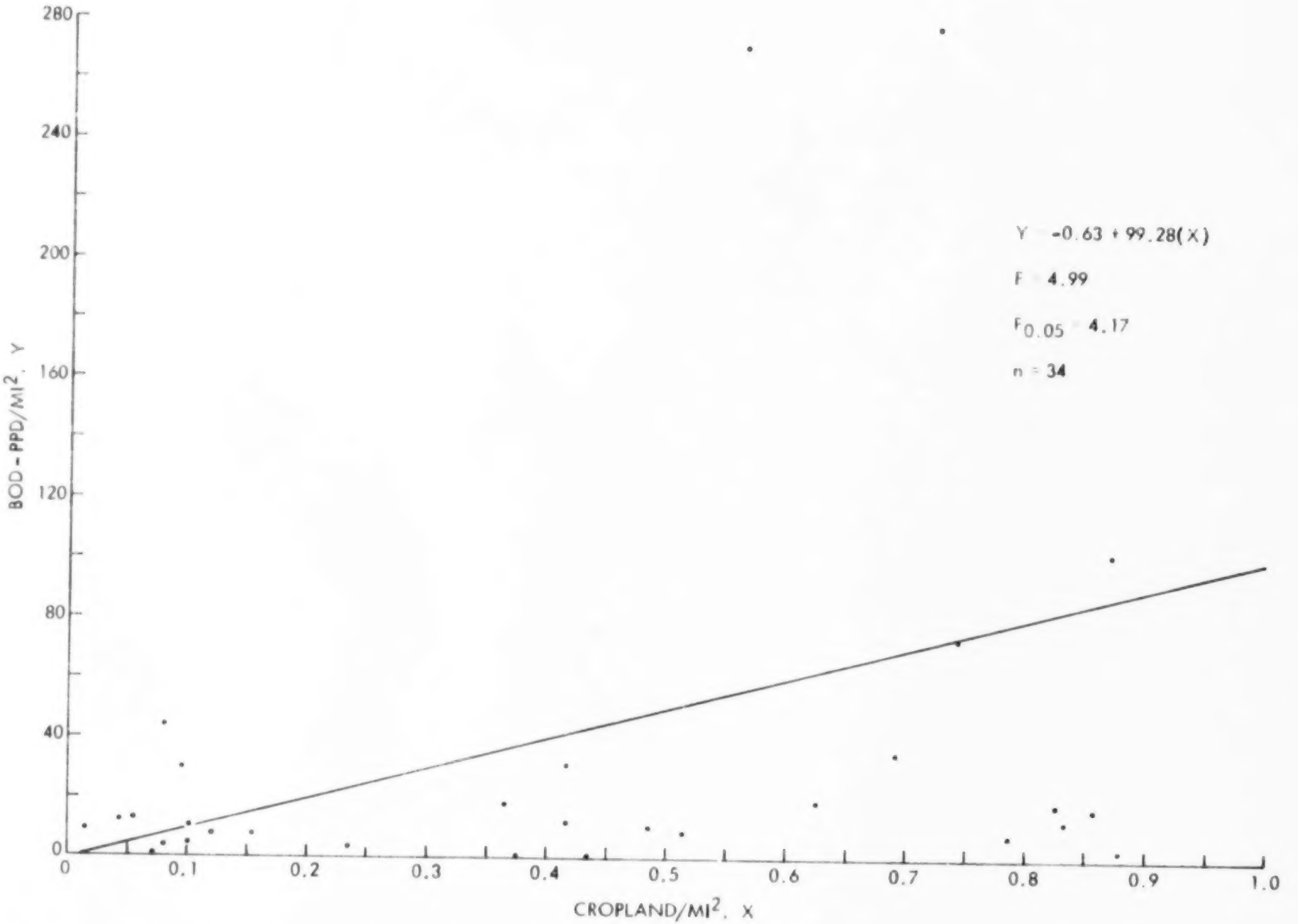

Figure 31. Regression of BOD-PPD per square mile versus cropland per square mile

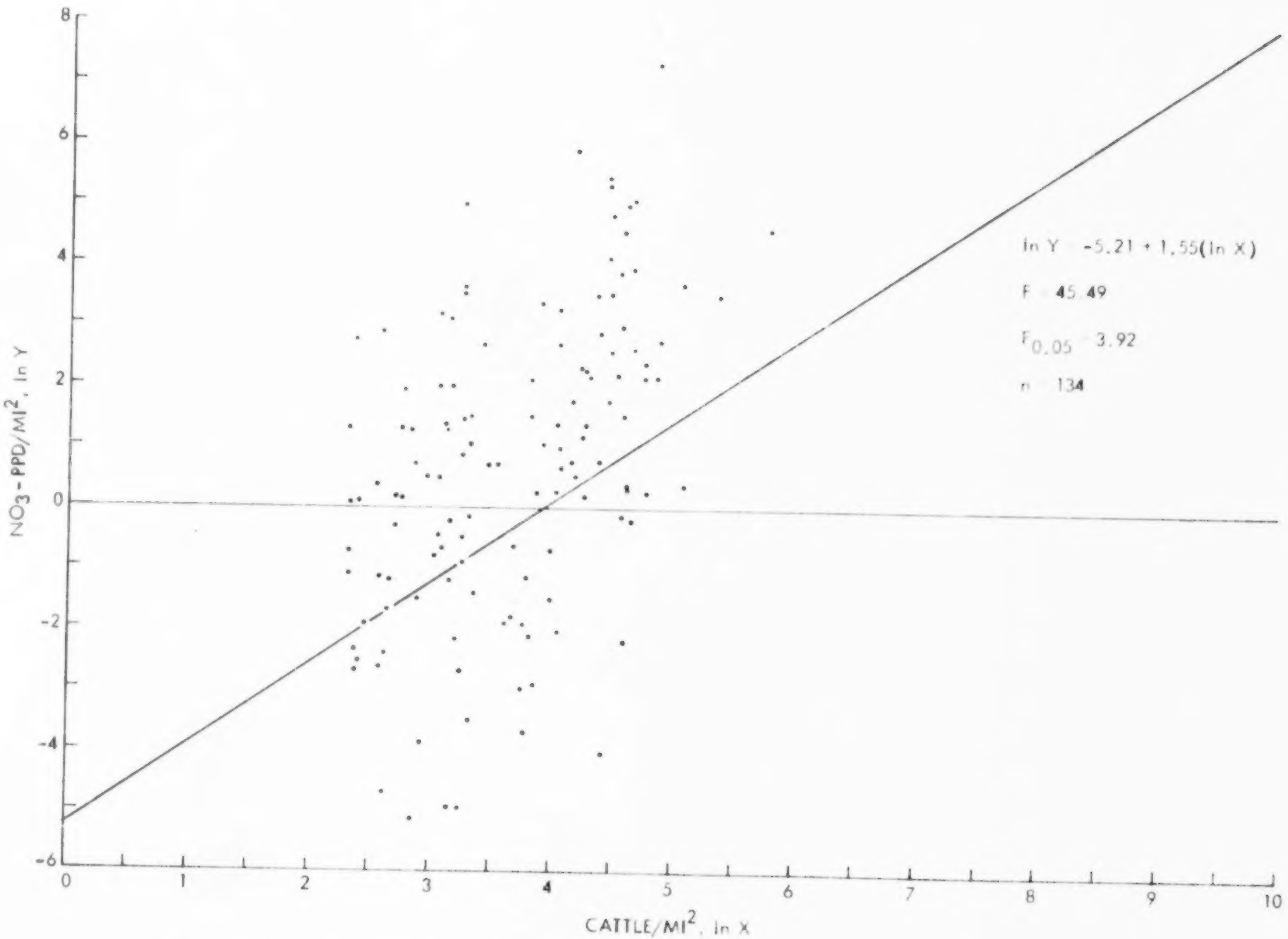

Figure 32. Regression of NO_3-PPD per square mile versus cattle per square mile

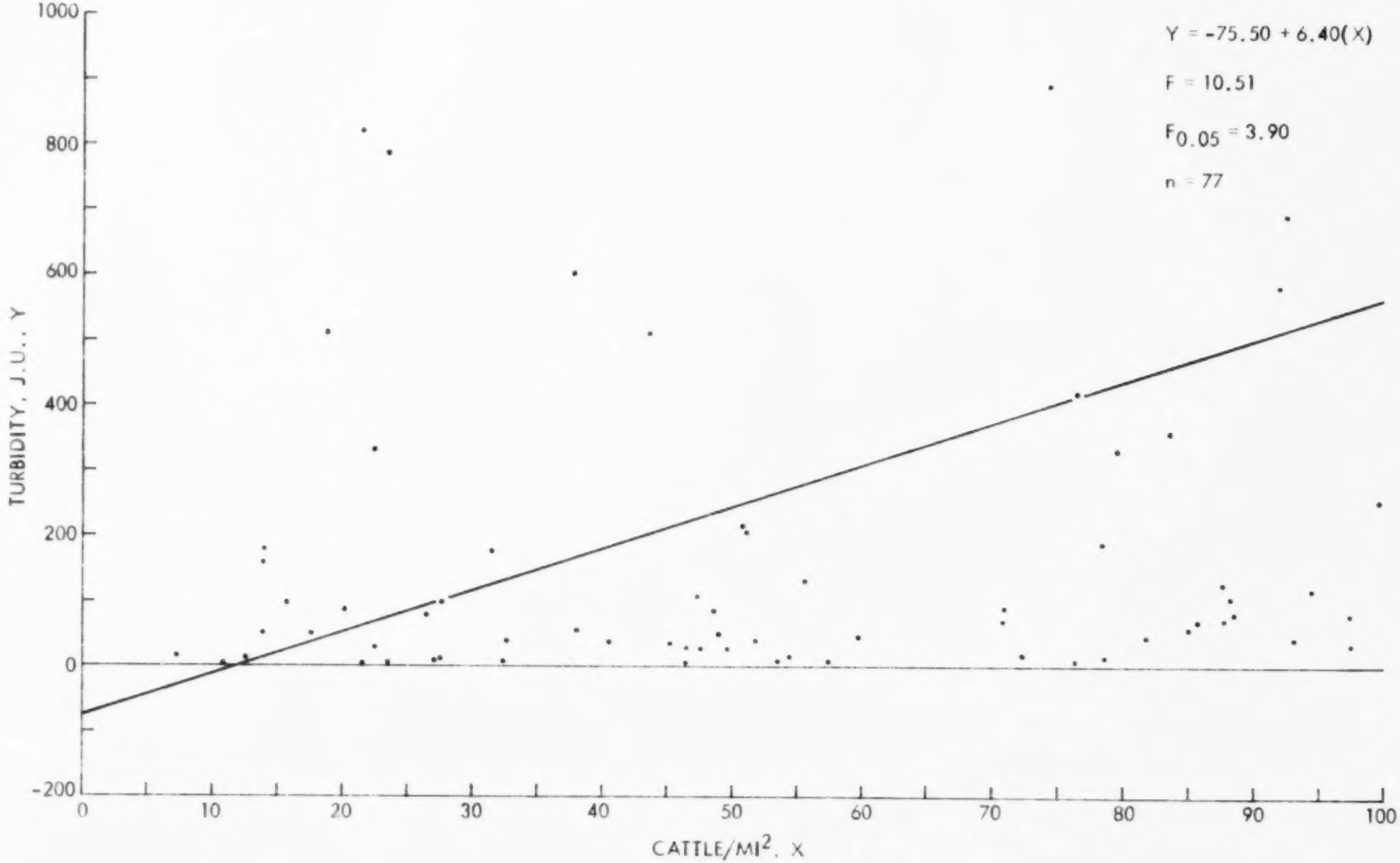

Figure 33. Regression of turbidity, JU versus cattle per square mile

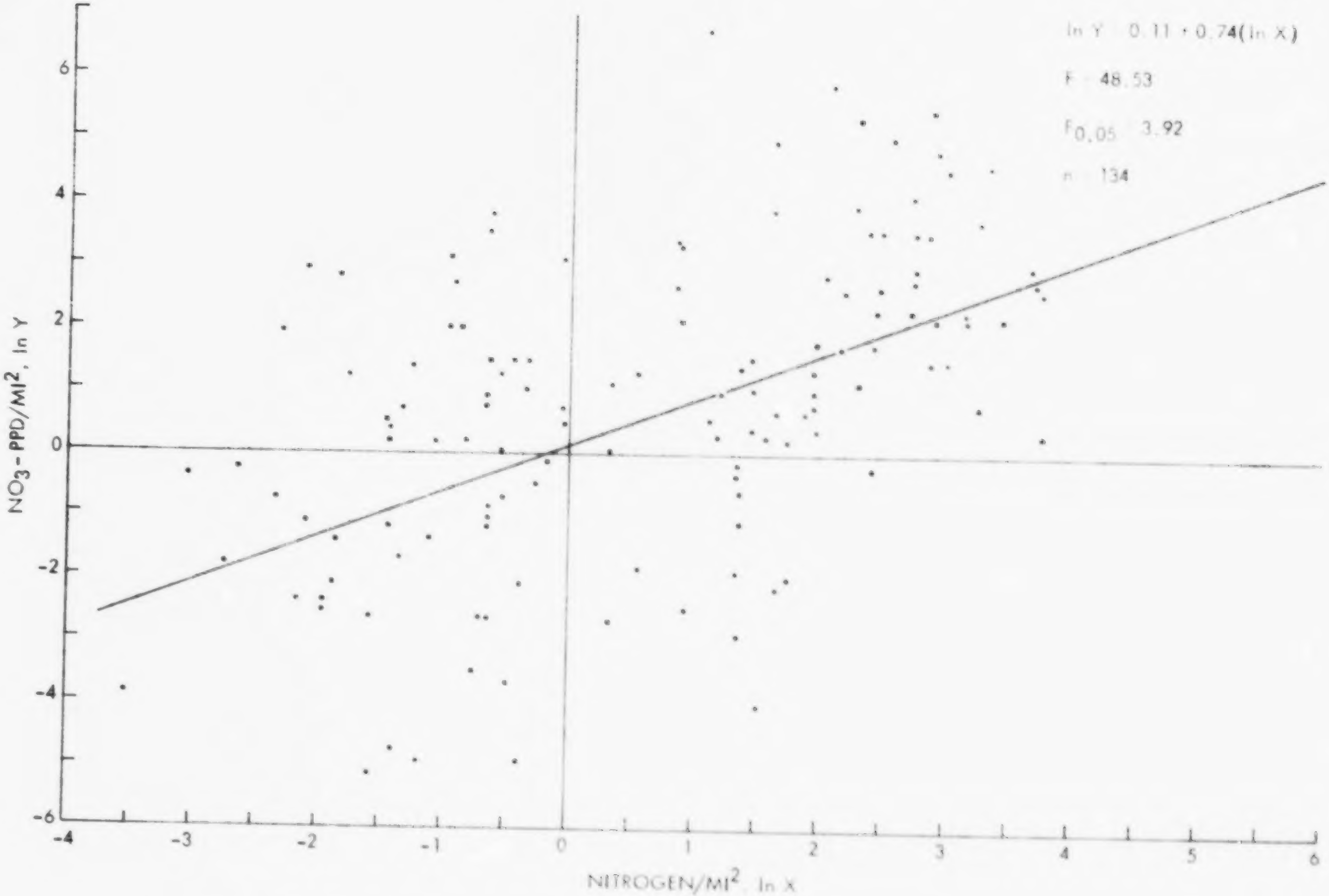

Figure 34. Regression of NO_3-PPD per square mile versus nitrogen per square mile

Thus turbidity x flow rate was used as a dependent variable in the regression analysis.

The eight analyses were carried out for multiple regression on the following four dependent variables: (1) turbidity (JU) x flow (ft^3/sec) per square mile, (2) BOD (lb/day) per square mile, (3) nitrate (lb/day) per square mile, and (4) turbidity (JU) per square mile. Both natural logarithmic transformations of data as well as the normal data were used in the regressions.

The regression equations are of the general form

$$Y_i = C_i + \sum_{j=1}^{n} A_{i,j} * X_{i,j}$$

where C = Constant

A = Coefficient

X = Independent variable

Y = Dependent variable

Ten independent variables were chosen for analysis. These included: (1) cropland in $mile^2/mile^2$ of the basin area; (2) pasture land in $mile^2/mile^2$; (3) irrigated cropland in $mile^2/mile^2$; (4) number of cattle $/mile^2$; (5) number of $hogs/mile^2$; (6) nitrogen fertilizer in $tons/mile^2$; (7) phosphate fertilizer in $tons/mile^2$; (8) rainfall amount in in/year; (9) slope percent class; and (10) cover factor.

The values of cover factor and livestock were evaluated on a weighted basis, consistent with values reported in the literature. The cover factor was computed by dividing all the land in a watershed into four groups (viz., row crops, small grain, pasture and hay, and woodland), and assigning a weight to each group. Thus, row crops were weighted 0.45, small grain 0.2, pasture, 0.02, and wooded land 0.005.[1] The sum of all the four weighted groups is divided by the area of the watershed, resulting in the weighted cover factor.

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[1] Great Lakes Basin Framework Study, Appendix No. 18, "Erosion and Sedimentation," Draft No. 3, Work Group on Erosion and Sedimentation, September 1971, pp. 18-33 (for row crops, cover factor was modified to reflect adequate management conditions).

Table 11 shows a summary of the results of the multiple regression analyses, including the coefficient of variation for each regression equation.

Each of these equations describes a correlation between a dependent water quality parameter and several independent parameters which include land use characteristics, physiographic characteristics and other related parameters which affect water quality in the streams of the Missouri Basin. These correlations are not, however, strictly valid beyond the conditions existing when regression data were collected.

The complexity of the regression equation increases if either the number of independent parameters increases, or true "independence" among these parameters does not exist. Both these conditions must be recognized in these analyses in properly interpreting the significance of the regressions.

BOD loading is represented in Table 11 by an equation containing six independent parameters, and may be written as follows:

BOD, lb/mile^2/day = -24.3 - 374.5 (cropland, mile^2/mile^2)

+260.0 (irrigated land, mile^2/mile^2) - 0.4 (cattle/mile^2)

-1.7 (hogs/mile^2) + 5.4 (rainfall, in/year) + 2,831 (cover factor).

Similarly, nitrate loading is related to seven independent parameters as shown by the equation,

NO_3, lb/mile^2/day =

-1.3 + 114.7 (cropland, mile^2/mile^2)

-322.5 (irrigated land, mile^2/mile^2)

+0.3 (cattle/mile^2) - 0.4 (hogs/mile^2) +

1.1 (nitrogen applied, tons/mile^2/year) +

1.0 (rainfall, in/year) + 578.1 (cover factor).

Table [illegible]. SUMMARY OF MULTIPLE REGRESSION ANALYSES

General equation: $Y(I) = C(I) + \sum_{J=1}^{10} A(I,J) \cdot X(I,J)$

Dependent variables

X(1) = Cropland/mile²
X(2) = Pasture land/mile²
X(3) = Irrigated land/mile²
X(4) = Cattle/mile²
X(5) = Hogs/mile²
X(6) = Nitrogen/mile²
X(7) = Phosphate/mile²
X(8) = Rainfall
X(9) = Slope-Percent-Class
X(10) = Cover Factor

Independent variables

Y(1) = Observed value of turbidity (JU) × flow rate (cfs)
Y(2) = Observed value of BOD lb/mile²/day
Y(3) = Observed value of NH_3 lb/mile²/day
Y(4) = Observed value of turbidity (JU)
C = Constant
A = Regression coefficient

Y(I)	C(I)	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Degrees of Freedom DF	Statistic F	If Significant at 95% Confidence *	Value of Y(I)
Y_1	-361.0	4,405.[illegible]	-	-	6.[illegible]	+10.2	-	-	11.3	310.6	23,098	6, 40	1.62	*	342.9
Y_2	-24.2	-374.5	-	803.0	+0.4	-1.7	-	-	5.3	-	2,811	6, 74	6.34	*	34.9
Y_3	-1.3	116.7	-	-272.8	0.3	-1.6	1.1	-	1.0	-	578.1	8, 113	7.11	*	13.6
Y_4	-0.1	1.3	-	-	-	-	-	0.1	-	0.6	10.4	7, 77	4.51	*	0.6

lnY(I)	C(I)	$\ln X_1$	$\ln X_2$	$\ln X_3$	$\ln X_4$	$\ln X_5$	$\ln X_6$	$\ln X_7$	$\ln X_8$	$\ln X_9$	$\ln X_{10}$	DF	F	*	lnY(I)	Y(I)
$\ln Y_1$	-8.[illegible]	-4.[illegible]	-	-	2.3	0.2	-	0.3	-1.1	1.3	0.4	[illegible], 10	0.51		-2.81	0.06
$\ln Y_2$	-0.8	+2.1	-	+0.03	+0.03	-0.7	-	-	2.0	-	1.2	6, 26	1.13		3.29	26.84
$\ln Y_3$	-11.2	-1.9	-0.2	-0.1	1.8	-0.3	0.6	-	1.2	-	0.8	8, 112	7.55	*	2.24	9.34
$\ln Y_4$	-8.[illegible]	-2.0	-	-	1.5	-0.2	-	-0.3	0.9	0.5	1.5	[illegible], 73	2.56		0.61	1.84

Both these equations were shown to be significant at 5% level. Using these equations, it was calculated that 34.9 lb BOD_5/mile^2/day and 13.6 lb NO_3/mile^2/day are being discharged into the Missouri River Basin.

Similar calculations using natural logarithms yield 26.84 lb BOD/mile^2/day and 9.34 lb NO_3/mile^2/day. However, the regression equation for BOD based on logarithms was shown to be not significant at 5% level.

A review of Table 11 indicates that the usefulness of multiple regression equations is presently limited to the current data base and the regions under study. The following are comments that can be made of Table 11.

1. These multiple regressions are the results of analyses relating selected nonpoint source variables to water quality parameters, based on massive historical data. These regressions show that correlations do exist among independent variables and dependent variables. However, the results are still preliminary and have limited value for use in making prediction of water quality. Particularly, these equations should not be used to predict water quality outside of the Missouri River Basin where a different structure of relationship might be expected.

2. Careful scrutiny is required for all variables that are included in the multiple regression equations even though they were found to be significant in a bivariate regression analysis. Some regression coefficients are not physically justified with regard to their sign and/or magnititude. This might have been caused by the close interrelationship often called "multicollinearity" among the "independent variables". Multicollinearity may not be an obstacle in itself when a regression equation is to be used for prediction; but it can be a serious problem when one wishes to draw conclusions about the causal effects of specific independent variables.

3. The nonpoint source factors are related to the water quality parameters through some variables which were not included in the regressions, particularly those variables which relate to pollutant generation and to pollutant transport. These variables were necessarily omitted because adequate data do not exist, or because factors have not been identified. As a result, these regression equations should not be used directly to interpret "cause-and-effect" relationships, nor should they be utilized in attempts to control water pollution by changing the values of the few independent variables included in these regressions.

Consequently, we feel strongly that further collection and analysis of specific data are warranted. Recommendations for specific actions are made in Section VI.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

The components of a generalized nonpoint pollution model are: (1) natural source characteristics--rainfall, soil characteristics, slopes--which help to determine what the land is used for, and also define inherent tendencies to generate or release pollutants; (2) man-induced source characteristics--essentially the land use pattern, including inputs of potential pollutants such as pesticides and fertilizers; (3) properties of the pollutant (water solubility, absorption characteristics, lifetimes, chemical transformations); (4) pollutant generation and transport mechanisms and rates, which are functions of (1), (2), and (3); and (5) water quality data which reflect pollutant inputs from both nonpoint and point sources. The Data Bank generated in Phase I and evaluated in Phase II(A) contains extensive information on Items 1, 2, and 5, i.e., natural and man-induced characteristics of the land, and the quality of water in the Missouri River Basin. It contains essentially no information on the properties of potential pollutants and on the mechanisms involved in transport of these pollutants from the land to surface waters. This program to date has consisted of an evaluation of the possibility that useful nonpoint models might be constructed by a systematic analysis of a voluminous body of data which exclude Item 3, pollutant properties, and Item 4, mechanisms and rates of pollutant transport. Model development did not exclude the use of existing information on pollutant properties and transport mechanisms. However, information in these areas was generally inadequate.

The program also involved tests of the adequacy or completeness of data on land and water characteristics relevant to model development. In this regard, three questions have been asked: (1) are data on parameters included in the Data Bank accurate or reliable?; (2) are individual parameters reported for a high percentage of the stations, so that coverage is adequate?; and (3) are additional parameters useful or necessary?

The sum total of the correlations, plots, and subbasin-by-subbasin analysis presented in Section IV quite obviously comprises an overall model of present (1969) water quality in relation to nonpoint sources of pollution. This model has limited predictive capabilities, and efforts to extract equations which quantitatively relate specific effects to causes met with partial success. Several conclusions developed from the Phase II(A) study which relates to the above questions and to the structuring of further study are presented below, followed by an assessment of the overall significance of the study relative to advancing a capability to quantify nonpoint pollution, assess its impact, and develop effective overall control measures.

CONCLUSIONS

Specific conclusions drawn from Phase II(A) are as follows:

A General Model

The data base very clearly indicates that increasingly intense analysis of agricultural operations is accompanied by increasing water pollution. This fact is apparent from inspection of data, and is confirmed by computerized mathematical analysis. The significance of this is considered to be greater than a mere confirmation of accepted knowledge and theory, for it has been obtained for a large, real world system described by a massive body of data. It confirms research plot and research watershed results, on a greatly expanded scale. The present study also has yielded apparent exceptions to expected correlations. Explanations of these apparent exceptions, developed in further study, should prove to be an important part of the body of knowledge of nonpoint pollution, particularly with regard to interactions between natural factors and man-induced factors. In further study, time can profitably be spent on refinement of the general model developed in Phase II(A), with emphasis on development of a rationale for summing up agricultural activities and relating the sum to water quality.

Source-Pollutant Models

Analyses to date have yielded certain specific cause/effect equations which pass tests for validity over the entire basin, but which do not adequately describe selected subsets of data (subbasin data). The equations have a basic defect in that all of the load of a particular pollutant, except sometimes for a constant baseline load, appears to come from only one of a few of the total number of known sources. It has been concluded that the regression models developed in Phase II(A) permit one to state with confidence that, supported by statistical tests, a basinwide correlation between a water quality parameter and a source or sources exists; the regression models are not, however, sufficiently well developed or understood to permit their use in calculation of stream pollutant loads. In our judgment, further development or analysis aimed at specific and quantitative models, and based on a purely statistical approach, will not be fruitful with the present Data Base. This conclusion does not rule out further statistical analysis aimed at strengthening tentative conclusions, and refining and expanding correlations.

Test Results Consistent with Accepted Theory

The basinwide analysis of data by computerized methods yielded overall results which are consistent with accepted concepts and known facts about nonpoint pollutants. Nitrate, BOD, and turbidity (suspended sediment) correlate with intensities of agricultural operations; these pollutants should be related in a straightforward manner to runoff and the density of tillage, livestock, fertilizer, etc. Certain other pollutants, notably phosphorus, dissolved solids, and dissolved oxygen did not correlate with land use intensity. Phosphorus emissions are determined in part by geochemistry, and phosphorus deposited in streams is heavily adsorbed on deposited silt. Dissolved salts are influenced heavily by geochemistry, and dissolved salt concentrations are notably higher in the less heavily farmed regions of the basin. Dissolved oxygen levels are generally fairly high in the Missouri Basin; while DO responds broadly to agricultural intensity, other factors such as natural reaeration are apparently pronounced enough that DO is not a sensitive measure of pollutional inputs.

One can justifiably be pleased that analyses of a very broad data base confirm expectations based on known properties of pollutants and accepted theories regarding generation and transport mechanisms. This aspect of the results of data analyses (i.e., that correlations were found with cause/effect parameters which should in theory correlate strongly, and were not found where correlations might be expected to be weak) is strong evidence that the Data Bank presents an adequate and honest picture of land use and water quality in the Missouri Basin.

Gaps in Water Quality Data

Water quality data for the 233 stations varies in completeness or adequacy from parameter to parameter. Particularly noticeable is the scarcity of available data on pesticides and BOD. Model development is not feasible for pesticides. BOD is reported for only 68 of the 233 stations (29%). With these two exceptions, coverage of water quality parameters is adequate for the 233 stations.

Land Use Coverage

Land use coverage is on the whole excellent. Coverage based on the county unit has been calculated for the areas represented by each of the 233 stations, and can readily be compiled for other geophysical boundaries as has been done for the 13 subbasins.

Land use data in the Data Bank were acquired directly from available data compilations, with two exceptions--namely fertilizer and pesticide use. Data on these two parameters were obtained by questionnaire (pesticides) and calculation from available information (fertilizer use).

Partial updating of the Data Bank can be effected annually if desired. This process can be accomplished most easily every 5 years, however, by computer accession to the Census of Agriculture. Special procedures would be required in the updating process for collection or estimation of pesticide and fertilizer use at the county level.

Coverage of Basic Land Properties

Data on basic land or area properties are extensive, and of high quality. The potential usefulness of the Data Bank could, however, be substantially increased by addition of certain information. Of particular interest are the following:

* Precipitation mass balance data: runoff, infiltration, and evapotranspiration.

* Soil property data: the USDA is in the process of an extensive characterization of soils throughout the country in terms of basic soil properties, many of which relate to water quality and nonpoint pollution. In addition, soil losses (erosion) have been calculated for basic land uses throughout the United States; this information is a prime candidate for inclusion in the Data Bank, after it has been studied to determine how it might best be used.

Adequacy of Spatial Representation of the Basin

The average watershed associated with each of the 233 stations is over 2,000 miles^2 in area. Each station represents the quality of water in about 300 miles of surface streams, and reflects pollutional inputs from a large watershed which is extensively diversified in land use.

In order to achieve the ultimate objective of development of stream-source models, it is essential that the water quality stations uniformly interact with their respective watersheds. For example, the load of nitrate or BOD at a station should either be the cumulative load deposited throughout the watershed, or some uniform percentage of that load. With the possible exception of dissolved salts, none of the standard array of water pollutants will be truly conservative over such long stretches of rivers, and the "load" at a station will be a fraction of the deposited load. With 233 stations representing large watersheds of differing sizes and basic characteristics, one is not surprised to find that source-to-station watershed relationships are reasonably uniform for some pollutants, and are not for others. The size of the watershed represented by a water quality station appears, therefore, to be a critical factor, and the results of this study indicate that 2,000+ miles^2 is on the verge of being too large.

Success in allocating total loads of specific pollutants among several sources (either multiple sources of the same type, or different types of sources) is highly dependent on the nature of the station-watershed relationship. A large load deposited 30-50 miles upstream may, for example, register the same as a small load deposited 1-5 miles upstream of the station. It is self-evident that the specificity of source-station relationships will improve as the size of the watershed is diminished. This study had only limited success in efforts to distribute loads among several sources, which leads to the conclusion that the watersheds are too large and contain too diverse an array of sources to permit achievement of this objective.

This limitation of the Data Bank and its applicability to nonpoint modeling can be stated in another way, as follows. The water quality at a station in a surface stream is a rather complex function of the locations and quantities of discharge upstream of the station, and of physical/chemical/biological processes in the stream. The larger the watershed, and the more diverse it becomes, the greater is the uncertainty in pinpointing pollutant contributions from specific sources, even though the water quality and source characteristic data may be both complete and accurate. The results of this study tend to indicate that the water quality station/watershed combinations available for this study are sufficient in number to permit development of satisfactory relationships depicting general interactions between basic land use patterns and water quality, but are usually insufficient in number to permit specific and quantitative description of source-stream interactions.

The above conclusion will no longer hold if the sources themselves can be more completely described. For example, sediment losses from the varying land uses can be predicted, and the incorporation of data or functions for sediment losses in the Data Bank would permit a more accurate and specific modeling of erosion and of sediment deposition in streams. Similarly, a model for nitrogen cycle and transport within the environment could be combined with land use data to calculate quantities of nitrogen discharged from specific sources and combinations of sources.

Overall Adequacy of the Data Bank

Whether or not the Data Bank is considered to be adequate depends on the intended use. If the desired use is description of land use, land characteristics, and water quality in such a manner that broad stream-land use relationships can be easily visualized, and changes in these relationships followed over extended time periods, the Data Bank can be considered to be very nearly adequate, and updating activities need little expansion in scope or in data coverage. If, on the other hand, further model development is the objective, and if it is desired in addition that the Bank become a vital part of a long-term planning and management system which encompasses water quality, nonpoint pollution control, and land and resource management for the Missouri Basin, it is evident that the Bank is inadequate. In this regard, consideration should be given to the following:

a. Selective addition of water quality stations. This process should take place with the long-term future in mind, and include possible restructuring of the present system of water quality stations.

b. More complete coverage of BOD.

c. Inclusion of point source information.

d. Significantly upgraded coverage of pesticides in surface waters.

e. Expanded, more specific, data on pesticide and fertilizer use.

f. Inclusion of data on runoff and infiltration.

g. Inclusion of systematized data on soil losses.

h. Addition of basic geochemical data, and of basic data on soil properties.

OVERALL ASSESSMENT

The Phase II(A) program was initiated with the expectation that the groundwork established in Phase I and Phase II(A) would be the basis for continuing nonpoint modeling activities in a Phase II(B) program. This expectation was tempered by a realization that the Phase II(A) study could yield results and conclusions which might necessitate a reexamination of objectives and/or a reassessment of methods for achievement of objectives. The investigators have, as indicated in the conclusions presented earlier, come to a three-part overall assessment.

1. The Missouri River Basin Data Bank is a quite useful collection in that it affords the means to (a) depict clearly the basinwide interdependence between land use and water quality, (b) demonstrate by mathematical techniques that certain water pollutants are related to land use, and (c) show, also by mathematical means, that other water pollutants are either less simply related to land use, or that other factors obscure simple relationships. However, this Data Bank has basic limitations and inadequacies--

in its present state--which preclude detailed development of predictive models, and will limit continuing study to further analyses of trends and correlations. Further study of this type will be more dependent on scientific bias and investigator input, and less dependent on statistical data analysis.

2. Information and data required for useful expansion and updating is at hand, and model development can proceed in an orderly fashion if the additions are made.

3. The Data Bank is a unique and excellent base for updating and expansion to serve several purposes--water quality management planning, nonpoint source control and agriculture resource management, and land use analysis and planning. The utility of the Data Bank will be enhanced by systematic addition of a variety of data which relates broadly to water and resource management.

RECOMMENDATIONS

Several options for continuing study have been considered. One option is a Phase II(B) follow-on to the present program based upon the current Data Bank with significant additions, and incorporation of submodels such as the Soil Loss Model as an essential part of continuing model development. A second option involves intensive study of one or two subbasins, and would include the use of a model such as EPA's Auto Qual.[1/] A third option consists of development of a master plan for upgrading and maintaining the Data Bank, including designation of additional water quality stations and delineation of all data which should be accumulated and reported routinely. These options are elaborated upon below.

Continuing Basinwide Model Development

As stated earlier, the Data Bank in its present form limits model development to further analysis of trends and correlations. More of this type of analysis can profitably be conducted, but the greatest pay-off will come from analysis of a Data Bank expanded in such a manner that it includes information or data which relate to the mechanisms and rates of generation and transport of specific pollutants. Of first priority is the inclusion of available data on erosive losses of soils.

1/ "Auto-Qual Modelling System," U.S. Environmental Protection Agency, Office of Air and Water Programs, Washington, D.C. (1973) (Supplement I - Modification for Nonpoint Source Loadings.)

The U.S. Department of Agriculture has documented certain information by Land Resource Area (LRA), and other information by county, which together will permit a systematic calculation of sheet/rill erosion throughout the Missouri Basin as a function of land use. Data by LRA includes:

- Slope (S), slope length (L), and erodibility factor (K) (factors in the Universal Soil Loss Equation)[2/] for soil capability classes (a total of 29 possible class/subclass designations).

- Calculated soil loss data for cropland in the soil capability classes, with various typical crop rotations, tillage practices, and conservation practices.

The county data, presented in the Conservation Needs Inventory, include:

- Acreages of crops, hay, pasture, and other land uses, by soil capability class.

- Acreages of cropland under adequate conservation practices.

The data on K, S and L, in combination with R (rainfall factor) values (available from USDA handbooks), yield the basic erodibility of land, i.e., RKSL, a factor which one multiplies by a cover factor C and a practice factor P to calculate sheet/rill erosion. The cover factor C is known for various types of crops, and the practice factor P is a known factor for various conservation practices. It is within our means, therefore, to include in the Data Bank all the information needed to calculate sheet/rill erosion losses throughout the Missouri Basin. An additional refinement involves a factor termed the delivery ratio, which is that fraction of soil lost from fields which actually reaches a stream bed. Delivery ratios are a function of soil type and drainage area size; while less precisely established than the factors of the Universal Soil Loss Equation, accepted values are available. Delivered sediment to streams is therefore calculable, with information presently at our disposal.

The importance of sediment as a pollutant has been both under- and over-emphasized. Our investigators view sediment as a very significant pollutant in its own right, but not necessarily the most important one.

[2/] Wischmeier, W. H., and D. D. Smith, "Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains," Agriculture Handbook No. 282, ARS-USDA, May 1965.

except perhaps in situations where streams/reservoirs are flagrantly fouled with sediment. Sediment is, on the other hand, perhaps the most important of the nonpoint pollutants in that it is a carrier of other pollutants (nutrients, pesticides, metals, organics, bacteria, etc.), and for the additional reason that it serves as an indicator of other pollutants. One would expect, therefore, to find a strong correlation between nutrient emissions and emissions of sediment.

For these reasons, it is strongly recommended that specific soil loss information be developed for inclusion in the Data Bank, and that the following analyses be conducted:

- Calculation of sediment emissions to streams, by subbasin, and for the 233 watersheds represented by the Station Master File.
- Development of relationships between sediment emissions and stream turbidity and suspended solids loadings.
- Mathematical analyses of possible relationships and correlations between sediment emissions and other water quality parameters, such as nitrate, phosphorus, and coliforms. If statistical tests are favorable, define models which relate sediment emission to emissions of as many other pollutants as justified by adequacy of data.
- Analysis of the relative contributions of such pollutants as nitrogen and phosphorus from different sources such as cropland in row crops, cropland in small grains, and livestock.
- Delineation of projected sediment emissions which would be the result of implementation of assumed control procedures, and extension of projections to other sediment-related pollutants.

Continuing study aimed at model development should include three additional activities. The first activity consists of further study of fertilizers and pesticides addressed jointly to improving the information in the Data Bank on use patterns and to development of models which are source-specific (i.e., associate emitted quantities with livestock populations and cropping patterns).

The second activity consists of a renewed, essentially continuing examination of recent (about 1970 to the present) data entered into, and available from various data compilations. Some of the newer data may be useful for increasing the reliability of the 1969-based data now in the Bank. Year-to-year trends may perhaps be perceptible by visual examination.

The third activity consists of the study of other known and available data compilations, assessment of possible utility in the Data Bank, and addition of such new types of data (other than soil loss information discussed above) as will improve the capability to analyze and model nonpoint pollution. Data on runoff and infiltration are potentially useful, as is any information which helps to evaluate natural background levels of pollutants.

Subbasin Modeling

The entire Missouri River Basin is too large to be a suitable working tool for intensive study aimed at specific and precise model development. Within the basin there are, however, many macro-scale "watersheds" (each several hundred to a few thousand square miles in area) which represent differing rural environments and will serve as excellent tools for detailed model development. In a well-planned study, such modeling activities could be complemented by evaluations of the efficacy of nonpoint pollution control processes.

In a study limited to one or two of these subbasins or watersheds, it will be feasible to update land use to the current condition; to collect samples and measure water quality at a preselected number of stations in addition to existing stations; and to verify and apply a water quality model to be used for projections and to assist in analyzing defects or voids in the information base. The EPA "Auto Qual" Model is a candidate for use in such a study. The water quality model would provide the means to calculate what happens to nonpoint pollutants (and point pollutants as well) after they reach surface waters, so that water quality data can be more accurately matched with data on pollutant inputs.

Such an undertaking should not be casually initiated, for a few sobering uncertainties exist. Chief among these is the problem of dealing with slug inputs of pollutants when much of the existing water quality data is not specifically related to slug inputs. An extensively instrumented and monitored micro watershed or research plot is a much more comfortable laboratory. The macro watershed must be the eventual testing and proving ground for nonpoint models, however. In a large and relatively complex area it will be possible to begin to identify and quantify interactions between sources and/or pollutants on the land, and to assess effects which are due primarily to the relatively long, sometimes circuitous pathways along which pollutants travel in the real world of a complete agricultural watershed.

The recommended subbasin modeling activity thus involves significantly larger areas, or watersheds, than are currently under study in research programs, and makes use of current and available data on land use and water quality, supplemented to a modest extent by added water quality stations and collection of other new data.

Development of a Master Plan for Data Bank Maintenance

Present national priorities are very strongly directed to several issues or questions which hinge on land and water qualities, and land and water resource values. Key issues are energy production/conservation, food production, ultimate waste disposal, hazardous and toxic substance control, mineral resource development, disease and pest control through chemical and biological agents, and preservation of the water resource for various beneficial uses.

No one will dispute the need for a system which provides for accumulation, storage, and retrieval of information and data related to these issues. This quite obviously is no simple undertaking, even with computers at hand. Data on land characteristics, land use, and water quality are foundation information for such a system. Accessory information of potential value includes land used for waste disposal, pesticide use, fertilizer use, and point source generation and dispersal of hazardous wastes, toxic substances, and water pollutants.

The Missouri River Basin Data Bank contains much of the above-named information, some comprehensively, and some less than adequately. Furthermore, programs and mechanisms have been developed which permit retrieval and versatile manipulation of stored data.

Continuing development and use of the Data Bank should be conducted with a two-fold objective:

a. To refine and extend its relevance and utility in nonpoint pollution assessment and modeling; and

b. In recognition of other needs and issues, to lay the groundwork for expanding the base of information and broadening its utility.

It is recommended, therefore, that a use-oriented study be conducted with the objective of developing a plan for expanding the Missouri River Data Bank and developing it to the point that it is a mature system which meets several needs. The study should include the following:

- Assessment of the extent and availability of information, and whether provisions have been made for updating transient data.

- Development of a data needs list, and justification of need through specification of use.

- Development of a list of candidate information uses, and specification of data manipulation requirements for these uses.

- Development of data acquisition needs, such as added water quality stations or addition of parameters at existing stations.

- System analysis of the above in the framework of ADP capabilities and limitations, and formulation of one or more feasible Data Bank system together with plans for implementation.

This program obviously could be structured to be very ambitious and quite broad in scope. A sensible restriction on ambitions and scope is embodied in the following statement: the Missouri River Basin Data Bank contains what seem to be the basic building blocks of a broadly useful system, in a usable format; it is appropriate to obtain through further study and analysis a definition of potential scope and breadth of use, and to then formulate and present development/implementation options of varying ambition and urgency, so that we can sensibly select one or more to act upon.

APPENDIX A

DATA SOURCES

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The data base developed during Phase I study contained the following categories of data which was collected from various data sources and organized in a computer retrievable/processible form.

WATER QUALITY DATA

Water quality data were arranged according to physical, chemical, and biological parameters. Data from the Office of Water Data Coordination (OWDC) contained information concerning number, frequency, and location of important water quality monitoring stations.

A large fraction of the water quality data available for the Missouri River Basin was collected, particularly (a) those data available from EPA's STORET system, and (b) the tabulated data from USGS between 1965 and 1970. Information from those two data sources and from other sources have been summarized by the MBIAC,* and that summary has also been obtained. Much of the water quality data is in computer-processible form, e.g., the STORET system and the USGS system.

Two other sources of water quality data which may contain a significant amount of information are operating statements from both sewage treatment and water treatment plants. While some portion of this information is reported to EPA and put into STORET, most of it can be obtained from state files or the treatment plant themselves. We did not expand our current data bank to include these point sources.

HYDROLOGICAL DATA

Hydrological data can be divided into the following categories: stage, discharge, peak stage, low flow, cross section, flow duration, flood frequency, coefficient of roughness, time of travel, and surface inflow-outflow. The two principal sources of data on these parameters are the USGS and the Corps of Engineers.

The USGS publishes hydrologic data each year for each state in the basin. We obtained their data for the 1965 to 1970 period for most states in the basin. Besides being published in tabular form, these data are available in computer-processible form. The USGS operates more than 1,000 surface water stations in the basin with at least 40 stations in every basin state with the exception of Minnesota. Of these 1,000 stations, over 900 report daily discharge, and other data less frequently. The frequency of hydrologic data acquisition was almost always greater than for water quality measurements.

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* Missouri Basin Interagency Committee.

The Corps of Engineers takes hydrologic data for use in its reservoir and channel straightening work. Most of the information obtained is put into the USGS computer system. The Corps also publishes flood plain studies for specific watersheds.

A less important source of hydrologic information for the Missouri River Basin is the River Forecast Center of National Oceanic and Atmospheric Administration (NOAA) in Kansas City. It has developed long-term hydrographs for 800 subbasins which encompass the entire Missouri Basin plus an additional quarter-million square miles. These subbasins average about 1,000 miles^2, but may be as small as 200 to 400 miles^2. With these hydrographs and computer models for runoff, NOAA can successfully predict river stages along the Missouri River.

CLIMATOLOGICAL DATA

Climatological factors of most importance to our study are precipitation and temperature. Because of interest over a long period of time, much data have been collected. The principal source of these data is the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, North Carolina.

The quantity and quality of climatological data obtainable from NOAA are excellent and are believed to be sufficient for our study. A secondary source of data is MBIAC reports which present climatological information for the Missouri River Basin in either graphical or tabular form. These reports were prepared from the NOAA data.

LAND USE DATA

Land use in the Missouri River Basin can be divided into the following: agriculture, recreation, urban, military, grassland, wildlife areas, forest areas, and water areas. The sources of land use data include the various branches of the U.S. Department of Agriculture--the Statistical Research Service, the Agricultural Stabilization and Conservation Service, the Forest Service, and the Soil Conservation Service. Each state also has a Department of Agriculture which collects land use data. The Department of the Interior has land use data in several branches such as the Bureau of Reclamation.

There are at least five major types of compilations of land use data. One of the most important is the Conservation Needs Inventory. Two Conservation Need Inventories have been published, one for 1958 and the other for 1967. The 1958 inventory contains data on land use and conservation treatment needs by county for the entire United States. Statistics include cropping patterns with yield and projected yield by resource area, soil resource group, and subbasin. The inventory information is correlated with the soil classification data in the Missouri Basin; the correlations are on tape and are available at the Missouri Basin Interagency Committee Office in Lincoln, Nebraska. The inventory includes all land use except built-up areas and land owned by the federal government.

The 1967 inventory includes all acreage except urban and built-up acres, and all land owned by the federal government other than cropland operated under lease or permit. Estimates of needs for conservation treatment for each major land use were based on the acreages and conditions of the land or the vegetative cover as of the crop year 1967.

The 1967 Conservation Needs Inventory is available on magnetic tape. On a county basis, the data include land capability class and subclass, information on acreage of corn and sorghum, other row crops, close grown crops, summer fallow, total field crops, rotation hay and pasture, hay land, conservation use only, temporarily idle cropland, total tillage rotation, orchard, vineyards and bush fruit, open lands formerly cropped, and total cropland.

The next major source of land use information is the Census of Agriculture for 1969. This census includes detailed land use data by county for each state of the union. The 1969 Census is available on tape and includes 1964 statistics for comparison with 1969 figures. For each county, data include information about all farms, such as the number, the acreage in the farms, and the land use. It includes the size of the farms, the farm operator tenure, farm income and sales, farm production expenses, machinery and equipment, amounts of livestock and poultry, and crops harvested. It also contains some data on irrigation and artificial drainage as well as agricultural chemicals and commercial fertilizer use. The crops are divided into corn, sorghum, hay, feed, field seeds, strawberries, small grains, soybeans, peanuts, potatoes, tobacco, cotton, vegetables, tree fruit and grapes, nursery and greenhouse products, and forest products.

Another source of information on crops and land use is the Agricultural Stabilization and Conservation Service of the USDA, which has a summary by county of all farms which participate in the ASCS program. This summary represents over 75% of all farms. Through the year 1970, the data covered wheat, cotton, and feed grains, but the 1971 report is more extensive--going into more detail and including other grains. ASCS uses magnetic tapes for storing their data.

Another data source is the detailed data sheets compiled by counties for the Land Resource Appendix of the Missouri Basin Comprehensive Framework Study. These working papers include land use data for public lands which are not available in the Conservation Needs Inventory. The papers are of value because they present a single source of data on use of these public lands. These data are located otherwise in several government agencies having legal jurisdiction over these lands, i.e., Bureau of Land Management, Forest Service, Bureau of Reclamation, and Corps of Engineers.

A final source of land use information is state cropland and livestock data. All states in the Missouri Basin provide an annual or biannual agricultural census and keep records of major crop acreages and of the number of livestock on farms on a county basis. For most Missouri Basin states, these reports have been compiled for many years (10 to 40 years). While these data are not as detailed as the Conservation Needs Inventory or Census of Agriculture, they represent an annual data source.

TOPOGRAPHIC DATA

The topographic information needed for modeling work includes items such as tributary location, basin elevation, drainage area, river mileage, river width, river body slope, drainage area slope, etc. The primary data source here is the USGS topographical maps having scales of 1:24,000 and 1:250,000, which are available for the entire basin. These two types of maps present equal elevation contour intervals of 10 ft and 50 ft, respectively, and can be used to estimate the values of the previously mentioned parameters. However, it would require a considerable amount of time and effort to transfer this information from maps to tables. Fortunately, except for the drainage area slopes, most of the needed topographic data have been compiled by the following agencies.

MBIAC

A report entitled "Condensed Tabulation of River Mileage and Drainage Areas," published in 1965, lists for approximately 900 gauged tributaries (1) gauge location, (2) mileage above the mouth, (3) noncontributing area, and (4) drainage area. This publication is a supplement to the 1949 edition of the Corps of Engineers "Missouri River Basin-River Mileages and Drainage Areas."

USGS

Gauge locations and drainage areas are always listed in their annually published "Water Resources Data." The river body slope, stream length, river width, drainage area, and other characteristics of gauged and ungauged sites are available at the USGS district offices.

SOIL CLASSIFICATION DATA

The types of soil directly influence the quality and quantity of pollutant in the surface runoff and the agricultural practices on the lands. Furthermore, the agricultural practices greatly affect the water quality of the streams. Soil classification data, therefore, are extremely important in modeling work.

A very important method of classification for the purposes of our study was found to be based on the sediment yield of the soil. Based on this parameter, the SCS delineated and classified the soil areas into seven categories. These data have been used to develop a soil map for all the plains states. The map does not include those parts of the basin in Missouri, Iowa, and Minnesota. However, they are presently capable of completing the basin area not shown on the Great Plains map.

The Soil Conservation Service also has a wealth of other data relating to soil type, land use and topography. These data are available in soil surveys on a county-by-county basis. However, soil surveys are not available for each county in the basin and some of them are quite old, but they are still unusually good information sources.

LIVESTOCK DATA

Data on livestock are available from the State Agriculture Boards on a county basis. Livestock inventories are taken at least semiannually (on 1 January and at mid-year), and livestock marketing information is reported monthly.

The categories of livestock reported are as follows:

- Milk cows that have calved
- Other cattle
- Hogs and pigs
- Sheep and lambs
- Chickens
- Turkeys

The number of cattle feedlots and the number of fed cattle marketed are also reported, although the size of operation constituting a commercial feedlot varies among states.

FERTILIZER DATA

Information on fertilizer consumption is available in great detail on a county basis throughout the Missouri River Basin. The tonnage of fertilizer sold (in 14 categories) is reported for about 40 different grades and types of fertilizer. The totals are published twice yearly for each county.

Fertilizer data are also collected and published annually in The Fertilizer Supply by the U.S. Department of Agriculture's ASCS, and by its Statistical Report Service in summary form by states. The Census of Agriculture reports the number of farms on which fertilizers are applied for each county, the number of acres fertilized, the tons of fertilizer applied, and the farmers' expenditures on fertilizers.

PESTICIDES

There are no reliable data available on a county basis regarding pesticide applications, other than those published in the Census of Agriculture. The Census reports farm expenditures on a county basis for pesticides for various uses, and the number of acres on which the pesticides were used. These data, along with information obtained or obtainable from other sources, provide a reasonably sound basis for estimating the extent and type of pesticide application on a county level.

Estimating Pesticide Applications

Pesticide applications are estimated on a county level, utilizing several different data sources and techniques:

a. Total production and consumption of pesticides in the U.S., as reported annually by ASCS.

b. Pesticide expenditures and acres treated for each county, as reported in the Census of Agriculture for selected years.

c. A mail survey of county extension agents to determine local pesticide application practices.

Much of the pesticide data was obtained by a survey of county extension agents.

APPENDIX B

DATA ORGANIZATION

The significant achievement of Phase I study was the compilation of all pertinent data in a logical fashion, which allows easy access for whatever analysis might be desired.

The collected data were originally generalized on the basis of three separate systems: data on water quality and hydrology come from the stream stations at which they were monitored; data for slope, soil classification, land use, livestock distribution, fertilizer use, and pesticides use are available by counties; and precipitation data are from each weather station. We related all data to a common base--the watershed. To achieve this, the county-watershed relationships and county-weather station relationships were determined and utilized to transform data from counties or weather stations into the watershed. The data system which resulted directly relates water quality parameters to physical, economic and climatological parameters. The present file has water quality data and hydrological data for 1968, 1969, and 1970, and land use data for 1969. However, provisions were made for updating when new data become available.

Two major computer files were produced for this program. The County Master File (Table B-1) has one record for each of the 438 counties in the Missouri River Basin. Records for each county consist of data on their land use, fertilizer and pesticide application, soil classification, livestock distribution, topography, and climatology. The Station Master File (Table B-2) contains information unique to an individual station and the watershed which impacts that station. In this file, the station location, the water quality and hydrological data, the area and physical characteristics of the watershed, and all information available for counties in the watershed are recorded in the County Master File are compiled. Two hundred thirty-three water quality stations were selected. These stations were chosen on the basis of their locations, and the type and frequency of their measurements. Identifications and locations of these stations are presented in the Phase I Final Report.[1/]

[1/] Vandegrift, A. E., and S. Y. Chiu, "Systems Programs for the Analysis of Nonurban, Nonpoint Source Pollutants in the Missouri Basin Region," Midwest Research Institute, Kansas City, Missouri (May 1973).

Table B-1. COUNTY FILE INFORMATION SHEET, 1969

State ____________ County ____________
Watershed ____________
Land Resource Area ____________ Land Resource Region ____________

Land Characteristics:

Soil Capability Classes (in acres)

I - ________
IIE - ________
IIW - ________
IIS - ________
IIC - ________
IIIE - ________
IIIW - ________
IIIS - ________
IIIC - ________
IVE - ________
IVW - ________
IVS - ________
IVC - ________
VE - ________
VW - ________
VS - ________
VC - ________
VIE - ________
VIW - ________
VIS - ________
VIC - ________
VIIE - ________
VIIW - ________
VIIS - ________
VIIC - ________
VIIIE - ________
VIIIW - ________
VIIIS - ________
VIIIC - ________

Slope Percent Class ____________ Soil Erosion Class ____________
Soil Name ____________ Rainfall Intensity ________ in/30 min
Total Precipitation ________ in. (Year) ________ in. (Spring) ________ in. (Summer) ________ in. (Fall) ________ in. (Winter)

Land Use (in Sq. Miles)

Total Land Area ________
Land in Farm ________
Other Land Area ________
Harvested Crop ________
Pasture Crop ________
Other Cropland ________
Total Cropland ________
Woodland ________
Irrigated ________
Other Farmland ________

Crop Data (in Sq. Miles)

Corn ________
Sorghums ________
Wheat ________
Other Small Grain ________
Soybeans ________
Hay ________
Cotton ________
Peanuts ________
Tobacco ________
Potatoes ________
Vegetables ________
Berries ________
Orchards ________
Other Crops ________
Greenhouse (Sq. Ft.) ________

Table B-1. (Concluded)

Fertilizer (tons):

	1st Half Year	2nd Half Year
Nitrogen	________	________
P_2O_5	________	________
K_2O	________	________

	Annual
Lime	________
Herbicide Applied	________
Insecticide Applied	________
Fungicide Applied	________

Livestock and Poultry:

Cattle and Calves (total) ________
  Cattle Feedlots (600+) ________
  Cattle in Feedlots (600+) ________

Hogs (total) ________
  Hoglots (200+) ________
  Hogs in Lots (200+) ________

Sheep (Total) ________
Horses and Ponies ________

Chickens (Total 3 Mo+) ________
  Chicken houses (1600+) ________
  Chickens in houses (1600+) ________

Table B-2. STATION FILE INFORMATION SHEET, 1969

Location:

Stream Name ____________ Location ____________
MRI Station Number ____________ OWDC Sub-Sub-Basin ____________
State ________ County ________ Latitude ________ Longitude ________
STORET Station ________ STORET Agency ________ OWDC WQ Station ______
OWDC SW Station ________ USGS Station ____________

Total Watershed Area ____________ Downstream Station ____________
Distance to Downstream Station ____________

Land Characteristics:

Main Channel Slope ______ ft/mi Slope Percent Class ____________
Soil Erosion Class ________ Soil Infiltration Rate _____ in/hr Soil Index ______ in
Soil Capability Classes (in acres)

I - ________
IIE - ________
IIW - ________
IIS - ________
IIC - ________
IIIE - ________
IIIW - ________
IIIS - ________
IIIC - ________
IVE - ________
IVW - ________
IVS - ________
IVC - ________
VE - ________
VW - ________
VS - ________
VC - ________
VIE - ________
VIW - ________
VIS - ________
VIC - ________
VIIE - ________
VIIW - ________
VIIS - ________
VIIC - ________
VIIIE - ________
VIIIW - ________
VIIIS - ________
VIIIC - ________

Rainfall Intensity ________ in/30 min
Total Precipitation ________ in. (Year) ________ in. (Spring) ________ in. (Summer) ________ in. (Fall) ________ in. (Winter)

ation Data: (Averages of Year, Spring, Summer, Fall, and Winter)

Temp. ___ ___ ___ ___ ___
D.O. ___ ___ ___ ___ ___
BOD ___ ___ ___ ___ ___
Total N ___ ___ ___ ___ ___
T.D.S. ___ ___ ___ ___ ___
NO_3 ___ ___ ___ ___ ___
PO_4 ___ ___ ___ ___ ___
T.S.S. ___ ___ ___ ___ ___
SO_4 ___ ___ ___ ___ ___
CL ___ ___ ___ ___ ___
T. Coliform ___ ___ ___ ___ ___
F. Coliform ___ ___ ___ ___ ___
Herbicides ___ ___ ___ ___ ___
Insecticides ___ ___ ___ ___ ___
Fungicides ___ ___ ___ ___ ___
Flow ___ ___ ___ ___ ___

Table B-2. (Continued)

Land Use: (Sq. Miles)

Total Land Area ____________
Land in Farm ____________
Other Land Area ____________

Harvested Crop ________
Pasture Crop ________
Other Cropland ________
Total Cropland ________
Woodland ________
Irrigated ________
Other Farmland ________

Crop Data: (Sq. Miles)

Corn ____________
Sorghums ____________
Wheat ____________
Other Small Grain ________
Soybeans ____________
Hay ____________
Cotton ____________
Peanuts ____________

Tobacco ____________
Potatoes ____________
Vegetables ____________
Berries ____________
Orchards ____________
Other Crops ____________
Greenhouses (Sq. Ft.) ________

Fertilizer Data: (Tons)

	1st Half Year	2nd Half Year
Nitrogen	____________	____________
P_2O_5	____________	____________
K_2O	____________	____________

	Annual
Lime	____________
Herbicide Applied	____________
Insecticide Applied	____________
Fungicide Applied	____________

Table B-2. (Concluded)

Livestock and Poultry:

Cattle and Calves (Total)______________
Cattle Feedlots (600+)______________
Cattle in Feedlots (600+)______________

Sheep (Total)______________
Horses and Ponies______________

Hogs (Total)______________
Hoglots (200+)______________
Hogs in Lots (200+)______________

Chickens (Total 3 Mo.+)______________
Chicken Houses (1,600+)______________
Chickens in Houses (1,600+)______________

Contributing Counties:(Up to 100 Counties)

State/County Code ______________
Total County Area______________
County Area to This Station______________
Distance from County to Station______________

County Code______________

APPENDIX C

DATA PROCESSING TECHNIQUES

We have developed the data processing procedures by converting the computer program originally developed for use on a Burroughs computer to be used on CDC/6600 System.

The conversion was needed because the available statistical package could not be used on the Burroughs computer, which is relatively slow and thus expensive. Direct conversion is not feasible due to dissimilarities of the two systems. Consequently, the data bank was transformed from Burroughs tape to an intermediate tape on IBM/360 from which the data are transformed onto a CDC/6600 System tape.

As it is expensive to run the CDC/6600 tape each time the data are processed, a separate data file was created which contains only selected parameter inputs on CDC/6600 requiring shorter core storage space. Backup data files, duplicates of original tapes, were created to avoid accidental loss of data.

The reduced version Data Bank contains essential information which can be automatically tabulated in data sets for each of the water quality monitoring stations located on discrete segments of the river tributary system. In this way, we can correlate the water quality vs land use parameters and other environmental factors by using standard statistical packages.

The data processing sequence, from the existing data bank on Burroughs 3500 tape to statistical analysis of data, is indicated in Figure C-1. The following sequential steps related to the creation of new data files were completed:

1. Conversion of the station master and county master tapes from B3500 to IBM/360, using the existing program.

2. Writing a 360 COBOL Program to convert the IBM/360 station master tape to an unpacked format acceptable to the CDC/6600.

3. Creation of the unpacked station master tape.

4. Writing a 360 COBOL Program to read the full station master tape and produce a reduced station data tape.

5. Creation of the reduced station data tape.

6. Development of programs to select data from the reduced tape for appropriate statistical analyses.

From unpacked data files created from the original computer tapes, data were reassembled in tabular form.

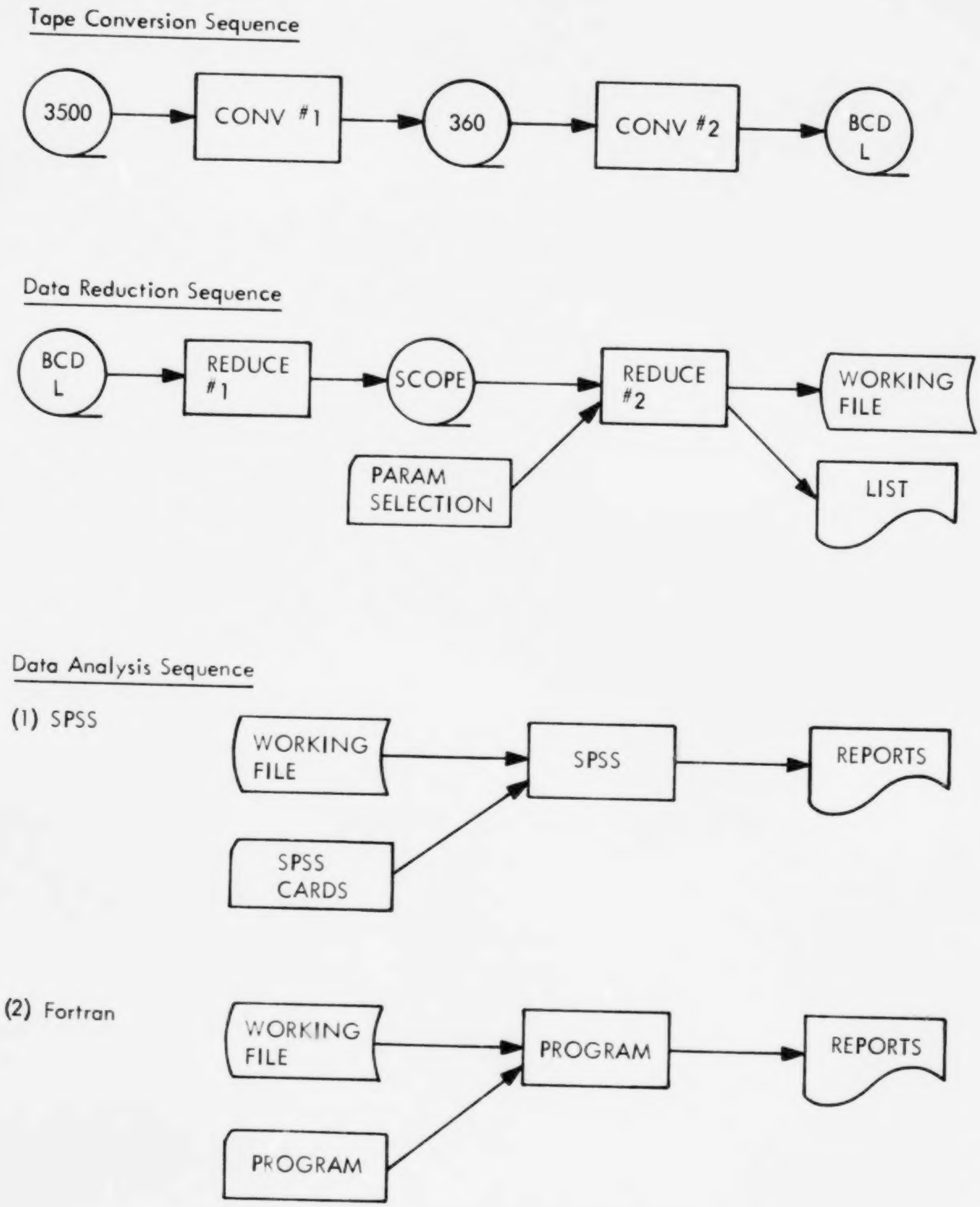
Tape Conversion Sequence
3500
CONV #1
360
CONV #2
BCD L
Data Reduction Sequence
BCD L
REDUCE #1
SCOPE
REDUCE #2
WORKING FILE
PARAM SELECTION
LIST
Data Analysis Sequence
(1) SPSS
WORKING FILE
SPSS
REPORTS
SPSS CARDS
(2) Fortran
WORKING FILE
PROGRAM
REPORTS
PROGRAM

Figure C-1. Data processing sequence

APPENDIX D

COMPUTER PROGRAMS

Automatic data processing for the current Phase II(A) study involved development of a number of computer programs. The system language used for these programs was COBOL, to be consistent with computer programs developed during Phase I. These programs are adaptable for FORTRAN language subroutines, and other scientific subroutine packages available commercially.

The following programs were developed during this study:

1. Conversion of Burroughs 3500 Tape of Station Master File to IBM/360 tape.

2. Creation of UNPACK file to unpack IBM/360 Station Master File.

3. Conversion of B3500 County Master File to IBM/360 tape.

4. Creation of a reduced Station Master File (REDUCE, CNVRT1, and CNVRT2).

5. "SORT" file to read 13 subbasin files.

6. "CNVRT3" file to add annual rainfall data to the file.

7. Sample program of SPSS Library subroutine for regressions and correlations.

8. Use of subfiles of SPSS to get tables showing coefficient of variation between predicted and observed values of dependent variables in multiple regression equations for each subbasin.

9. Print tables of independent variables and dependent variables giving correlation and regression analysis.

10. Program "SBASIN" to list tables of stations with valid observations for variables being analyzed.

11. Program to create a file (BDS 3807) from total Station Master with data to be analyzed and store tables on disk.

12. Program to print tables of all station values for variables to be analyzed.

1. CONVERSION OF BURROUGHS TAPE TO IBM
(STATION MASTER)

```
// JOB FIRST   CONVERT B3500 STATION MASTER TAPE TO IBM-360
// OPTION LOG.LINK
// EXEC ASSEMBLY
         TITLE <FIX BUCKETS IN STATION MASTER<                                  01010
V21B     START X<0<                                                             01020
R0       EQU   0                                                                01030
R1       EQU   1                                                                01040
R2       EQU   2                                                                01050
R3       EQU   3                                                                01060
R4       EQU   4                                                                01070
R5       EQU   5                                                                01080
R6       EQU   6                                                                01090
R7       EQU   7                                                                01100
R8       EQU   8                                                                01110
R9       EQU   9                                                                01120
R10      EQU   10                                                               01130
R11      EQU   11                                                               01140
R12      EQU   12                                                               01150
R13      EQU   13                                                               01160
R14      EQU   14                                                               01170
R15      EQU   15                                                               01180
         USING *.R2.R3.R4.R5.R6.R7.R8                                           01190
         BALR  R2.R0                                                            01200
         BCTR  R2.R0                                                            02010
         BCTR  R2.R0                                                            02020
         LA    R3.2048(R2)                                                      02030
         LA    R3.2048(R3)                                                      02040
         LA    R4.2048(R3)                                                      02050
         LA    R4.2048(R4)                                                      02060
         LA    R5.2048(R4)                                                      02070
         LA    R5.2048(R5)                                                      02080
         LA    R6.2048(R5)                                                      02090
         LA    R6.2048(R6)                                                      02100
         LA    R7.2048(R6)                                                      02110
         LA    R7.2048(R7)                                                      02120
         LA    R8.2048(R7)                                                      02130
         LA    R8.2048(R8)                                                      02140
         OPEN  STIN.STOUT                                                       02150
GETIN    GET   STIN                                                             02160
         LA    R9.PL40                                                          02170
         LA    R10.41                                                           02180
         BAL   R11.MVOLOOP4                                                     02190
*                                                                               02200
*                                                                               03010
         LA    R9.PL6401                                                        03020
         LA    R10.640                                                          03030
         BAL   R11.MVOLOOP6                                                     03040
*                                                                               03050
         LA    R9.PL511                                                         03060
         LA    R10.52                                                           03070
         BAL   R11.MVOLOOP4                                                     03080
*                                                                               03090
         LA    R9.PL6402                                                        03100
         LA    R10.640                                                          03110
         BAL   R11.MVOLOOP6                                                     03120
*                                                                               03130
         LA    R9.PL512                                                         03140
         LA    R10.52                                                           03150
         BAL   R11.MVOLOOP4                                                     03160
*                                                                               03170
```

```
         LA    R9,PL6403
         LA    R10,640
         BAL   R11,MVOLOOP6
*
         LA    R9,PL513
         LA    R10,52
         BAL   R11,MVOLOOP4
*
         LA    R9,PL6404
         LA    R10,640
         BAL   R11,MVOLOOP6
*
         LA    R9,PL514
         LA    R10,52
         BAL   R11,MVOLOOP4
*
         LA    R9,PL6405
         LA    R10,640
         BAL   R11,MVOLOOP6
*
         LA    R9,PL515
         LA    R10,451
         BAL   R11,MVOLOOP4
*
         PUT   STOUT
         B     GETIN
*
TAPEOF   EQU   *
         CLOSE STIN,STOUT
         EOJ
*
*
*
*
MVOLOOP4 EQU   *                      LOOP TO OFFSET FIELD
         MVO   0(4,R9),0(4,R9)        THAT IS 4 BYTES LONG
         OI    3(R9),X<0F<            AND IS ONLY POSITIVE.
         LA    R9,4(R9)
         BCT   R10,MVOLOOP4
         BR    R11
*
*
```

```
MVOLOOP6 EQU   *                    LOOP TO OFFSET FIELD
         MVC   SAVE.0(R9)           THAT IS 6 BYTES LONG
         MVO   0(6.R9).0(6.R9)      AND IS SIGNED.
         NI    5(R9).X<F0<
         TM    SAVE.X<D0<
         BO    NEG
         OI    5(R9).X<0C<
         B     NEXT
NEG      OI    5(R9).X<0D<
NEXT     LA    R9.6(R9)
         BCT   R10.MVOLOOP6
         BR    R11
         LTORG
SAVE     DS    CL1
*
*   STATION MASTER
*
STIO     DS    0CL22156
STID     DS    CL156
PL40     DS    40PL4
PL41     DS    PL4                  1
PL6401   DS    640PL6               SIGNED
PL511    DS    51PL4
PL42     DS    PL4                  2
PL6402   DS    640PL6               SIGNED
PL512    DS    51PL4
PL43     DS    PL4                  3
PL6403   DS    640PL6               SIGNED
PL513    DS    51PL4
PL44     DS    PL4                  4
PL6404   DS    640PL6               SIGNED
PL514    DS    51PL4
PL45     DS    PL4                  5
PL6405   DS    640PL6               SIGNED
PL515    DS    51PL4
PL400    DS    400PL4
*
*
STIN     DTFMT BLKSIZE=22156.DEVADDR=SYS010.EOFADDR=TAPEOF.             C
               IOAREA1=STIO.MODNAME=IJFFZZZZ.FILABL=NO.RECFORM=FIXUNB
*
STOUT    DTFMT BLKSIZE=22156.DEVADDR=SYS011.IOAREA1=STIO.FILABL=NO.     C
               MODNAME=IJFFZZZZ.TYPEFLE=OUTPUT
*
IJFFZZZZ MTMOD RECFORM=FIXUNB
         END   V218
/*
// EXEC LNKEDT
// ASSGN SYS010.X<182<
// ASSGN SYS011.X<183<
// EXEC
/*
/+
```

2. UNPACK IBM STATION MASTER

```
// JOB UNPACK   UNPACK THE IBM-360 STATION MASTER FILE
ALLOC F1=0K,F2=0K
// OPTION LOG,LINK
// ASSGN SYS004,X<130<
// EXEC FCOBOL
       IDENTIFICATION DIVISION.

       PROGRAM-ID. <UNPACK<

       AUTHOR.      RAY POSCH
                    MIDWEST RESEARCH INSTITUTE
                    KANSAS CITY, MO.

       REMARKS. THIS PROGRAM INPUTS THE IBM-360 VERSION OF THE STATION
                    MASTER FILE CONTAINING PACKED DECIMALS AND OUTPUTS
                    AN UNPACKED VERSION.

       ENVIRONMENT DIVISION.

       CONFIGURATION SECTION.
       SOURCE-COMPUTER.  IBM-360.
       OBJECT-COMPUTER.  IBM-360.

       INPUT-OUTPUT SECTION.

       FILE-CONTROL.
           SELECT STATION-FILE-INPUT    ASSIGN TO SYS001-UT-2400-S.
           SELECT STATION-FILE-OUTPUT   ASSIGN TO SYS002-UT-2400-S.

       DATA DIVISION.

       FILE SECTION.

       FD  STATION-FILE-INPUT
           LABEL RECORDS ARE OMITTED
           RECORD CONTAINS 22156 CHARACTERS
           DATA RECORD IS STATION-RECORD-IN.

       01  STATION-RECORD-IN.
           03  STATION-IDENT-IN              PICTURE X(156).
           03  STATION-DATA-IN               COMP-3.
               05  SD-IN                     PICTURE 9(7) OCCURS 40.
           03  STATION-DATA-BY-YEAR-IN       COMP-3 OCCURS 5.
               05  SDBY-1-IN                 PICTURE 9(7).
               05  SDBY-2-IN                 PICTURE S9(11) OCCURS 640.
               05  SDBY-3-IN                 PICTURE 9(7) OCCURS 51.
           03  COUNTIES-IN-STATION-IN        COMP-3.
               05  CIS-IN                    PICTURE 9(7) OCCURS 400.
       FD  STATION-FILE-OUTPUT
           LABEL RECORDS ARE OMITTED
           RECORD CONTAINS  3680 CHARACTERS
           DATA RECORD IS STATION-RECORD-OUT.

       01  STATION-RECORD-OUT.
           03  OUT-RECORD                    PICTURE X(3680).

       WORKING-STORAGE SECTION.
```

```
77  I                                PICTURE 9(3) COMP.
77  J                                PICTURE 9(3) COMP.

01  STATION-REC-OUT.
    03  STATION-IDENT-OUT            PICTURE X(156).
    03  STATION-DATA-OUT.
        05  SD-OUT                   PICTURE 9(8) OCCURS 40.
    03  STATION-DATA-BY-YEAR-OUT     OCCURS 5.
        05  SDBY-1-OUT               PICTURE 9(8).
        05  SDBY-2-OUT.
            07  SDBY-2-OUT-C         PICTURE 9(12) OCCURS 640.
        05  SDBY-2-OUT-R             REDEFINES SDBY-2-OUT.
            07  SDBY-2-OUT-D         OCCURS 640.
            09  SDBY-2-OUT-SIGN      PICTURE X.
            09  FILLER               PICTURE X(11).
        05  SDBY-3-OUT               PICTURE 9(8) OCCURS 51.
    03  COUNTIES-IN-STATION-OUT.
        05  CIS-OUT                  PICTURE 9(8) OCCURS 400.
    03  FILLER                       PICTURE X(4).
01  REC-OUT  REDEFINES STATION-REC-OUT.
    03  PRU-OUT                      PICTURE X(3680) OCCURS 12.

PROCEDURE DIVISION.

A000-CONTROL SECTION.

A001.
    NOTE    THIS SECTION CONTROLS THE EXECUTION
            OF THE PROGRAM.

A010-START.
    OPEN INPUT  STATION-FILE-INPUT.
    OPEN OUTPUT STATION-FILE-OUTPUT.

A020-READ-INPUT.
    READ STATION-FILE-INPUT
        AT END GO TO A030-STOP.
    PERFORM C000-UNPACK-AND-WRITE.
    GO TO A020-READ-INPUT.

A030-STOP.
    CLOSE STATION-FILE-INPUT.
    CLOSE STATION-FILE-OUTPUT.
    STOP RUN.

C000-UNPACK-AND-WRITE SECTION.

C001.
    NOTE    THIS SECTION BUILDS AND WRITES ONE
            STATION-FILE-OUTPUT LOGICAL RECORD.

C010-MOVE-ALPHA.
        MOVE STATION-IDENT-IN TO STATION-IDENT-OUT.

C020-MOVE-COMP.
    PERFORM C030-MOVE-STATION-DATA
            VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 40.
    PERFORM C040-MOVE-BY-YEAR
            VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 5.
    PERFORM C070-MOVE-COUNTIES
            VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 400.
    GO TO C100-WRITE-OUTPUT.

C030-MOVE-STATION-DATA.
    MOVE SD-IN (I) TO SD-OUT (I).
```

```
       C040-MOVE-BY-YEAR.
           MOVE SDBY-1-IN (I) TO SDBY-1-OUT (I).
           PERFORM C050-MOVE-WATER-DATA
                   VARYING J FROM 1 BY 1 UNTIL J GREATER THAN 640.
           PERFORM C060-MOVE-LAND-DATA
                   VARYING J FROM 1 BY 1 UNTIL J GREATER THAN 51.

       C050-MOVE-WATER-DATA.
           MOVE SDBY-2-IN (I J) TO SDBY-2-OUT-C (I J).
           IF SDBY-2-IN (I J) LESS THAN ZERO
               MOVE <-< TO SDBY-2-OUT-SIGN (I J).

       C060-MOVE-LAND-DATA.
           MOVE SDBY-3-IN (I J) TO SDBY-3-OUT (I J).

       C070-MOVE-COUNTIES.
           MOVE CIS-IN (I) TO CIS-OUT (I).

       C090-WRITE-PRU.
           MOVE PRU-OUT (I) TO OUT-RECORD.
           WRITE STATION-RECORD-OUT.

       C100-WRITE-OUTPUT.
           PERFORM C090-WRITE-PRU
                   VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 12.
/*
// EXEC LNKEDT
// ASSGN SYS001.X<184<
// ASSGN SYS002.X<180<.X<A8<
// EXEC
/*
/*
```

3. CONVERT COUNTY MASTER TO IBM

```
// JOB THIRD   CONVERT [illegible] COUNTY MASTER TAPE TO IBM-360
// OPTION LOG,LINK
// EXEC ASSEMBLY
         TITLE 'SHIFT BUCKETS IN COUNTY MASTERS'
V218     START X'5600'
R0       EQU   0
R1       EQU   1
R2       EQU   2
R3       EQU   3
R4       EQU   4
R5       EQU   5
R6       EQU   6
R7       EQU   7
R8       EQU   8
R9       EQU   9
R10      EQU   10
R11      EQU   11
R12      EQU   12
R13      EQU   13
R14      EQU   14
R15      EQU   15
         USING *,R2,R3
         BALR  R2,0
         BCTR  R2,0
         BCTR  R2,0
         LA    R3,2048(,R2)
         LA    R3,2048(,R3)
         OPEN  CNTYIN,CNTYOUT
GETIN    GET   CNTYIN,CNTYMSTR
         LA    R4,CNTYFLDS
         LA    R5,295
MVOLOOP  MVO   0(4,R4),0(4,R4)
         OI    3(R4),X'0F'
         LA    R4,4(R4)
         BCT   R5,MVOLOOP
         PUT   CNTYOUT,CNTYMSTR
         B     GETIN
*
TAPEOF   EQU   *
         CLOSE CNTYIN,CNTYOUT
         EOJ
*
*
*   COUNTY MASTER
CNTYMSTR DS    0CL1268
         DS    CL40
CNTYFLDS DS    295PL4
         DS    CL48
*
*
         LTORG
*
*
CNTYIN   DTFMT BLKSIZE=1268,DEVADDR=SYS010,EOFADDR=TAPEOF,             C
               IOAREA1=TRIN1,IOAREA2=TRIN2,MODNAME=IJFFZZWZ,           C
               FILABL=NO,RECFORM=FIXUNB,WORKA=YES
*
TRIN1    DS    CL1268
TRIN2    DS    CL1268
*
CNTYOUT  DTFMT BLKSIZE=1268,DEVADDR=SYS011,FILABL=NO,IOAREA1=TPOUT1,   C
               IOAREA2=TPOUT2,RECFORM=FIXUNB,TYPEFLE=OUTPUT,           C
               WORKA=YES,MODNAME=IJFFZZWZ
*
*
TPOUT1   DS    CL1268
TPOUT2   DS    CL1268
*
IJFFZZWZ MTMOD RECFORM=FIXBLK,WORKA=YES
*
         END   V218
/*
// EXEC LNKEDT
// ASSGN SYS010,X'182'
// ASSGN SYS011,X'183'
// EXEC
/*
/&
```

4. CREATE A REDUCED STATION MASTER FILE

```
CONVRT,T300,CM10000.
ACCOUNT,M350415,MIRWEST,3807C.
REQUEST,TAPEI,HY,X,C=3640.  /5405/ NO RING
SKIPF,TAPEI,1.
RFL,50000.
COBOL.
LGO.
SAVE,RTAPE.
RETURN,TAPEI.
REWIND,RTAPE.
REWIND,LGO.
RFL,50000.
COBOL.
LGO.
SAVE,TAPEX.
REWIND,TAPEX.
REWIND,LGO.
RFL,50000.
FTN.
LGO.
SAVE,STNFIL.
REQUEST,TAPEO,HY.          /22252/ RING IN
REWIND,STNFIL,TAPEO.
COPYBF,STNFIL,TAPEO,1.
RETURN,TAPEO.
UNSAVE,RTAPE.
UNSAVE,TAPEX.
RFL,10000.
GET,COST(LIBRARY)
COST.
EXIT.
RFL,10000.
GET,COST(LIBRARY)
COST.
&
       IDENTIFICATION DIVISION.

       PROGRAM-ID. "REDUCE"

       AUTHOR.        RAY ROSCH
                      MIDWEST RESEARCH INSTITUTE
                      KANSAS CITY, MO.

       REMARKS.       THIS PROGRAM READS THE UNPACKED STATION MASTER FILE
                           AND CREATES A REDUCED STATION DATA FILE.

       ENVIRONMENT DIVISION.

       CONFIGURATION SECTION.
       SOURCE-COMPUTER. 6600.
       OBJECT-COMPUTER. 6600.

       INPUT-OUTPUT SECTION.

       FILE-CONTROL.
           SELECT MASTER-STATION-FILE  ASSIGN TO TAPEI.
           SELECT REDUCED-STATION-FILE ASSIGN TO RTAPE.
           SELECT PRINT-FILE           ASSIGN TO OUTPUT.

       DATA DIVISION.
```

```
FILE SECTION.

FD  PRINT-FILE
    LABEL RECORD IS OMITTED
    RECORD CONTAINS 132 CHARACTERS
    DATA RECORD IS PRINT-LINE.

01  PRINT-LINE.
    03  CARRIAGE-CONTROL              PICTURE X.
    03  PRINT-DATA                    PICTURE X(131).

FD  MASTER-STATION-FILE
    LABEL RECORDS ARE OMITTED
    RECORD CONTAINS 3680 CHARACTERS
    DATA RECORD IS STATION-RECORD-IN.

01  STATION-RECORD-IN.
    03  RECORD-IN                     PICTURE X(3680).

FD  REDUCED-STATION-FILE
    LABEL RECORDS ARE OMITTED
    RECORD CONTAINS 2100 CHARACTERS
    DATA RECORD IS STATION-RECORD.

01  STATION-RECORD.
    03  STATION-IDENTIFICATION.
        05  STATION-NUMBER            PICTURE 9(8).
        05  STATE-NAME                PICTURE X(16).
        05  COUNTY-NAME               PICTURE X(16).
        05  STREAM-NAME               PICTURE X(16).
        05  LOCATION-NAME             PICTURE X(16).
        05  LATITUDE.
            07  DEGREES-LATITUDE      PICTURE 9999.
            07  MINUTES-LATITUDE      PICTURE 99.
            07  SECONDS-LATITUDE      PICTURE 99.
        05  LONGITUDE.
            07  DEGREES-LONGITUDE     PICTURE 9999.
            07  MINUTES-LONGITUDE     PICTURE 99.
            07  SECONDS-LONGITUDE     PICTURE 99.
    03  STATION-DATA.
        05  TOTAL-AREA                PICTURE 9(8).
        05  MAIN-CHANNEL-SLOPE        PICTURE 9(5)V9(3).
        05  RAIN-INTENSITY            PICTURE 9(5)V9(3).
        05  RAIN-EROSION-INDEX        PICTURE 9(5)V9(3).
        05  SLOPE-PCT-CLASS           PICTURE 9(5)V9(3).
        05  EROSION-CLASS             PICTURE 9(5)V9(3).
        05  SOIL-INFILTRATION         PICTURE 9(5)V9(3).
        05  SOIL-INDEX                PICTURE 9(5)V9(3).
        05  SOIL-CLASS-DATA.
            07  SOIL-TYPE             OCCURS 8.
                09  SOIL-CLASS-AREA PICTURE 9(8) OCCURS 4.
        05  SOIL-RESOURCE-DATA.
            07  SOIL-RESOURCE-TYPE  OCCURS 8.
                09  SOIL-RESOURCE-GROUP PICTURE 9(8) OCCURS 4.
    03  STATION-DATA-BY-YEAR.
        05  DATA-YEAR                 PICTURE 9(8).
        05  WATER-QUALITY.
            07  WATER-QUALITY-PERIOD  OCCURS 5.
                09  TEMPERATURE-F             PICTURE S9(9)V9(3).
                09  STREAMFLOW-CFS            PICTURE S9(9)V9(3).
                09  TURBIDITY-JU              PICTURE S9(9)V9(3).
                09  DISSOLVED-OXYGEN-MGL      PICTURE S9(9)V9(3).
                09  BIO-OXY-DEMAND-MGL        PICTURE S9(9)V9(3).
                09  TOTAL-PHOSPHORUS-MGL      PICTURE S9(9)V9(3).
                09  TOTAL-COLIFORM1-100ML     PICTURE S9(9)V9(3).
```

```
      05  STREAM-NAME-IN              PICTURE X(16).
      05  LOCATION-NAME-IN            PICTURE X(16).
      05  FILLER                      PICTURE X(56).
   03  STATION-DATA-IN.
      05  TOTAL-AREA-IN               PICTURE 9(8).
      05  MAIN-CHANNEL-SLOPE-IN       PICTURE 9(5)V9(3).
      05  RAIN-INTENSITY-IN           PICTURE 9(5)V9(3).
      05  SLOPE-PCT-CLASS-IN          PICTURE 9(5)V9(3).
      05  EROSION-CLASS-IN            PICTURE 9(5)V9(3).
      05  SOIL-INFILTRATION-IN        PICTURE 9(5)V9(3).
      05  SOIL-INDEX-IN               PICTURE 9(5)V9(3).
      05  FILLER                      PICTURE X(8).
      05  SOIL-CLASS-DATA-IN          PICTURE X(256).
   03  STATION-DATA-BY-YEAR-IN        OCCURS 5.
      05  DATA-YEAR-IN                PICTURE 9(8).
      05  WATER-QUALITY-IN.
         07  WATER-QUALITY-PERIODS-IN  OCCURS 5.
            09  STAT-TYPE-IN      OCCURS 64.
               11  STATISTIC-1 PICTURE S9(9)V9(3).
               11  STAT-1 REDEFINES STATISTIC-1.
                  13  STAT-SGN-1  PICTURE X.
                  13  STAT-VAL-1  PICTURE 9(8)V9(3).
               11  STATISTIC-2 PICTURE S9(9)V9(3).
      05  LAND-USE-CROPS-IN.
         07  LAND-AREA-IN             PICTURE 9(8).
         07  LAND-IN-FARMS-IN         PICTURE 9(8).
         07  OTHER-LAND-IN            PICTURE 9(8).
         07  TOTAL-CROP-AREA-IN       PICTURE 9(8).
         07  CROPLAND-HARVESTED-IN  PICTURE 9(8).
         07  PASTURE-GRAZING-IN       PICTURE 9(8).
         07  OTHER-CROPLAND-IN        PICTURE 9(8).
         07  WOODLANDS-IN             PICTURE 9(8).
         07  IRRIGATED-IN             PICTURE 9(8).
         07  OTHER-FARMLAND-IN        PICTURE 9(8).
         07  CORN                     PICTURE 9(8).
         07  SORGHUM                  PICTURE 9(8).
         07  WHEAT                    PICTURE 9(8).
         07  OTHER-GRAIN              PICTURE 9(8).
         07  SOYBEANS                 PICTURE 9(8).
         07  HAY-IN                   PICTURE 9(8).
         07  COTTON                   PICTURE 9(8).
         07  PEANUTS                  PICTURE 9(8).
         07  TOBACCO                  PICTURE 9(8).
         07  POTATOES                 PICTURE 9(8).
         07  VEGETABLES               PICTURE 9(8).
         07  BERRIES                  PICTURE 9(8).
         07  ORCHARDS                 PICTURE 9(8).
         07  OTHER-CROPS              PICTURE 9(8).
         07  GREENHOUSES              PICTURE 9(8).
      05  LIVESTOCK-IN.
         07  CATTLE-IN                PICTURE 9(8).
         07  FILLER                   PICTURE X(16).
         07  HOGS-IN                  PICTURE 9(8).
         07  FILLER                   PICTURE X(16).
         07  SHEEP-IN                 PICTURE 9(8).
         07  FILLER                   PICTURE X(8).
         07  CHICKENS-IN              PICTURE 9(8).
         07  FILLER                   PICTURE X(16).
      05  FERTILIZER-IN.
         07  FERTILIZER-PERIODS       OCCURS 2.
            09  NITROGEN-IN           PICTURE 9(8).
            09  PHOSPHATE-IN          PICTURE 9(8).
            09  POTASH-IN             PICTURE 9(8).
      05  PESTICIDE-IN.
         07  FILLER                   PICTURE X(8).
         07  HERBICIDE-IN             PICTURE 9(8).
```

```
                09  TOTAL-COLIFORM2-100ML   PICTURE S9(9)V9(3).
                09  FILTERED-RSD-MGL        PICTURE S9(9)V9(3).
                09  DISSOLVED-SOLIDS-TPD    PICTURE S9(9)V9(3).
                09  NITRATE-MGL             PICTURE S9(9)V9(3).
                09  HERBICIDE-TY            PICTURE S9(9)V9(3).
                09  INSECTICIDE-TY          PICTURE S9(9)V9(3).
                09  FUNGICIDE-TY            PICTURE S9(9)V9(3).
                09  UNUSED-1                PICTURE S9(9)V9(3).
                09  UNUSED-2                PICTURE S9(9)V9(3).
                09  UNUSED-3                PICTURE S9(9)V9(3).
                09  UNUSED-4                PICTURE S9(9)V9(3).
        05  WATER-STATISTICS        REDEFINES WATER-QUALITY.
            07  STATISTICS-PERIOD   OCCURS 5.
                09  WATER-STATISTIC PICTURE S9(9)V9(3) OCCURS 18.
        05  LAND-USE.
            07  LAND-AREA           PICTURE 9(8).
            07   LAND-IN-FARMS      PICTURE 9(8).
            07   OTHER-LAND         PICTURE 9(8).
        05  FARM-LAND.
            07  TOTAL-CROP-AREA     PICTURE 9(8).
            07   CROPLAND-HARVESTED PICTURE 9(8).
            07   PASTURE-GRAZING    PICTURE 9(8).
            07   OTHER-CROPLAND     PICTURE 9(8).
            07  IRRIGATED           PICTURE 9(8).
            07  OTHER-FARMLAND      PICTURE 9(8).
        05  CROPS.
            07  ROW-CROPS           PICTURE 9(8).
            07  SMALL-GRAIN         PICTURE 9(8).
            07  HAY                 PICTURE 9(8).
            07  WOODLANDS           PICTURE 9(8).
            07  C-FACTOR            PICTURE 9(5)V9(3) OCCURS 4.
        05  LIVESTOCK.
            07  CATTLE              PICTURE 9(8).
            07  HOGS                PICTURE 9(8).
            07  SHEEP               PICTURE 9(8).
            07  CHICKENS            PICTURE 9(8).
        05  FERTILIZER.
            07  NITROGEN            PICTURE 9(8).
            07  PHOSPHATE           PICTURE 9(8).
            07  POTASH              PICTURE 9(8).
        05  PESTICIDE.
            07  HERBICIDE           PICTURE 9(8).
            07  INSECTICIDE         PICTURE 9(8).
            07  FUNGICIDE           PICTURE 9(8).
        05  PRECIPITATION.
            07  RAINFALL            PICTURE 9(8) OCCURS 5.
    03  FILLER                      PICTURE X(92).

01  SEGMENTED-RECORD                REDEFINES STATION-RECORD.
    03  RECORD-DATA                 PICTURE X(100) OCCURS 21.

WORKING-STORAGE SECTION.

77  I               USAGE COMP      PICTURE 999.
77  J               USAGE COMP      PICTURE 999.
77  K               USAGE COMP      PICTURE 999.
77  S-VALUE                         PICTURE S9(9)V9(3).

01  STATION-REC-IN.
    03  STATION-IDENT-IN.
        05  STATION-NUMBER-IN       PICTURE 9(8).
        05  FILLER                  PICTURE X(12).
        05  STATE-NAME-IN           PICTURE X(16).
        05  COUNTY-NAME-IN          PICTURE X(16).
        05  LATITUDE-IN             PICTURE 9(8).
        05  LONGITUDE-IN            PICTURE 9(8).
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               07  INSECTICIDE-IN          PICTURE 9(8).
               07  FUNGICIDE-IN            PICTURE 9(8).
            05  PRECIPITATION-IN           PICTURE X(40).
        03  COUNTIES-IN-STATION-IN         PICTURE X(3200).
        03  FILLER                         PICTURE X(4).

    01  STATION-LOGICAL-REC                REDEFINES STATION-REC-IN.
        03  PRO-IN                         PICTURE X(3680) OCCURS 12.

    PROCEDURE DIVISION.

    A000-CONTROL SECTION.

    A001.
        NOTE     THIS SECTION CONTROLS EXECUTION
                 OF THE PROGRAM.

    A010-START.
        OPEN INPUT  MASTER-STATION-FILE WITH NO REWIND.
        OPEN OUTPUT REDUCED-STATION-FILE.
        OPEN OUTPUT PRINT-FILE.
        MOVE SPACES TO PRINT-DATA.

    A030-READ-RECORD.
        PERFORM A050-READ-PRO
            VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 12.
        PERFORM C000-REDUCE-DATA.
        GO TO A030-READ-RECORD.

    A050-READ-PRO.
        READ MASTER-STATION-FILE
            AT END GO TO A090-STOP.
        MOVE RECORD-IN TO PRO-IN (I).

    A090-STOP.
        CLOSE MASTER-STATION-FILE.
        CLOSE REDUCED-STATION-FILE.
        CLOSE PRINT-FILE.
        STOP RUN.

    C000-REDUCE-DATA SECTION.

    C001.
        NOTE     THIS SECTION BUILDS THE REDUCED
                 STATION DATA RECORDS.

    C010-REDUCTION-CONTROL.
        MOVE SPACES TO STATION-RECORD.
        PERFORM C030-MOVE-IDENT.
        PERFORM C050-MOVE-STATION-DATA.
        PERFORM C070-MOVE-BY-YEAR.
        PERFORM E000-OUTPUT.
        GO TO C900-EXIT.

    C030-MOVE-IDENT.
        MOVE STATION-NUMBER-IN TO STATION-NUMBER.
        MOVE STATE-NAME-IN     TO STATE-NAME.
        MOVE COUNTY-NAME-IN    TO COUNTY-NAME.
        MOVE STREAM-NAME-IN    TO STREAM-NAME.
        MOVE LOCATION-NAME-IN  TO LOCATION-NAME.
        MOVE LATITUDE-IN       TO LATITUDE.
        MOVE LONGITUDE-IN      TO LONGITUDE.

    C050-MOVE-STATION-DATA.
        MOVE TOTAL-AREA-IN         TO TOTAL-AREA.
        MOVE MAIN-CHANNEL-SLOPE-IN TO MAIN-CHANNEL-SLOPE.
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     MOVE RAIN-INTENSITY-IN      TO RAIN-INTENSITY.
     MOVE SLOPE-PCT-CLASS-IN     TO SLOPE-PCT-CLASS.
     MOVE EROSION-CLASS-IN       TO EROSION-CLASS.
     MOVE SOIL-INFILTRATION-IN   TO SOIL-INFILTRATION.
     MOVE SOIL-INDEX-IN          TO SOIL-INDEX.
     MOVE SOIL-CLASS-DATA-IN     TO SOIL-CLASS-DATA.

 C070-MOVE-BY-YEAR.
     MOVE 2 TO I.
     MOVE DATA-YEAR-IN (I) TO DATA-YEAR.
     PERFORM C090-MOVE-WATER-DATA
         VARYING J FROM 1 BY 1 UNTIL J GREATER THAN 5.
     MOVE LAND-AREA-IN (I)              TO LAND-AREA.
     MOVE LAND-IN-FARMS-IN (I)          TO LAND-IN-FARMS.
     MOVE OTHER-LAND-IN (I)             TO OTHER-LAND.
     MOVE TOTAL-CROP-AREA-IN (I)        TO TOTAL-CROP-AREA.
     MOVE CROPLAND-HARVESTED-IN (I)     TO CROPLAND-HARVESTED.
     MOVE PASTURE-GRAZING-IN (I)        TO PASTURE-GRAZING.
     MOVE OTHER-CROPLAND-IN (I)         TO OTHER-CROPLAND.
     MOVE WOODLANDS-IN (I)              TO WOODLANDS.
     MOVE IRRIGATED-IN (I)              TO IRRIGATED.
     MOVE OTHER-FARMLAND-IN (I)         TO OTHER-FARMLAND.
     ADD CORN (I)      SORGHUM (I)        SOYBEANS (I)      COTTON (I)
         PEANUTS (I) TOBACCO (I)        POTATOES (I)   VEGETABLES (I)
         ORCHARDS (I)   OTHER-CROPS (I)
             GIVING ROW-CROPS.
     ADD WHEAT (I)    OTHER-GRAIN (I) GIVING SMALL-GRAIN.
     MOVE HAY-IN (I)          TO HAY.
     MOVE CATTLE-IN (I)       TO CATTLE.
     MOVE HOGS-IN (I)         TO HOGS.
     MOVE SHEEP-IN (I)        TO SHEEP.
     MOVE CHICKENS-IN (I) TO CHICKENS.
     ADD NITROGEN-IN (I 1) NITROGEN-IN (I 2) GIVING NITROGEN.
     ADD PHOSPHATE-IN (I 1) PHOSPHATE-IN (I 2) GIVING PHOSPHATE.
     ADD POTASH-IN (I 1) POTASH-IN (I 2) GIVING POTASH.
     MOVE HERBICIDE-IN (I)     TO HERBICIDE.
     MOVE INSECTICIDE-IN (I) TO INSECTICIDE.
     MOVE FUNGICIDE-IN (I)     TO FUNGICIDE.
     MOVE PRECIPITATION-IN (I) TO PRECIPITATION.

 C090-MOVE-WATER-DATA.
     PERFORM C110-CONVERT-VALUE
         VARYING K FROM 1 BY 1 UNTIL K GREATER THAN 64.
     MOVE STATISTIC-1 (I J 02) TO TEMPERATURE-F (J).
     MOVE STATISTIC-1 (I J 03) TO STREAMFLOW-CFS (J).
     MOVE STATISTIC-1 (I J 04) TO TURBIDITY-JU (J).
     MOVE STATISTIC-1 (I J 07) TO DISSOLVED-OXYGEN-MGL (J).
     MOVE STATISTIC-1 (I J 09) TO BIO-OXY-DEMAND-MGL (J).
     MOVE STATISTIC-1 (I J 32) TO TOTAL-PHOSPHORUS-MGL (J).
     MOVE STATISTIC-1 (I J 42) TO TOTAL-COLIFORM1-100ML (J).
     MOVE STATISTIC-1 (I J 43) TO TOTAL-COLIFORM2-100ML (J).
     MOVE STATISTIC-1 (I J 51) TO FILTERED-RSD-MGL (J).
     MOVE STATISTIC-1 (I J 52) TO DISSOLVED-SOLIDS-TPD (J).
     MOVE STATISTIC-1 (I J 56) TO NITRATE-MGL (J).
     MOVE STATISTIC-1 (I J 62) TO HERBICIDE-TY (J).
     MOVE STATISTIC-1 (I J 63) TO INSECTICIDE-TY (J).
     MOVE STATISTIC-1 (I J 64) TO FUNGICIDE-TY (J).
     MOVE ZERO TO UNUSED-1 (J)  UNUSED-2 (J)
                  UNUSED-3 (J)  UNUSED-4 (J).

 C110-CONVERT-VALUE.
     IF STAT-SGN-1 (I J K) EQUALS "-"
         MULTIPLY STAT-VAL-1 (I J K) BY -1.0 GIVING S-VALUE
     ELSE MULTIPLY STAT-VAL-1 (I J K) BY +1.0 GIVING S-VALUE.
     MOVE S-VALUE TO STATISTIC-1 (I J K).
```

```
C900-EXIT.
    EXIT.

E000-OUTPUT SECTION.

E001.
    NOTE    THIS SECTION CONTROLS THE WRITING OF THE RECORD
            TO THE NEW FILE AND PRINTING OF THE DATA.

E010-OUTPUT-CONTROL.
    WRITE STATION-RECORD.
    PERFORM E030-PRINT-LINE
        VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 21.

E030-PRINT-LINE.
    MOVE RECORD-DATA (I) TO PRINT-DATA.
    IF I GREATER THAN 1
            MOVE SPACE TO CARRIAGE-CONTROL
        ELSE MOVE 0 TO CARRIAGE-CONTROL.
    WRITE PRINT-LINE.
&
IDENTIFICATION DIVISION.
PROGRAM-ID. "CNVRT1"
AUTHOR.     RAY POSCH
            MIDWEST RESEARCH INSTITUTE
            KANSAS CITY, MO.
REMARKS.    THIS PROGRAM READS THE COBOL FORMAT REDUCED STATION
                MASTER TAPE AND CREATES THE INTERMEDIATE
                FORTRAN COMPATIBLE TAPE.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER. 6600.
OBJECT-COMPUTER. 6600.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT STATION-MASTER-C  ASSIGN TO RTAPE.
    SELECT STATION-MASTER-F  ASSIGN TO TAPEX.
    SELECT PRINT-FILE        ASSIGN TO OUTPUT.
DATA DIVISION.
FILE SECTION.
FD  PRINT-FILE
    LABEL RECORD IS OMITTED
    RECORD CONTAINS 132 CHARACTERS
    DATA RECORD IS PRINT-LINE.
01  PRINT-LINE.
    03  CARRIAGE-CONTROL            PICTURE X.
    03  PRINT-DATA                  PICTURE X(131).
FD  STATION-MASTER-C
    LABEL RECORD IS OMITTED
    RECORD CONTAINS 2100 CHARACTERS
    DATA RECORD IS STATION-RECORD-C.
01  STATION-RECORD-C.
    03  SEG-1.
        05  DATA-1-A                PICTURE 9(8).
        05  DATA-1-B                PICTURE X(16).
        05  DATA-1-C                PICTURE X(16).
        05  DATA-1-D                PICTURE X(16).
        05  DATA-1-E                PICTURE X(16).
        05  DATA-1-F                PICTURE 9(8).
    03  SEG-2.
        05  DATA-2-A                PICTURE 9(8).
        05  DATA-2-B                PICTURE 9(8).
        05  SEG-2-C.
            07  DATA-2-C            PICTURE 9(5)V9(3) OCCURS 7.
    03  SEG-3.
        05  SEG-3-A         OCCURS 6.
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            07  DATA-3-A                PICTURE 9(8) OCCURS 10.
        05  SEG-3-B.
            07  DATA-3-B                PICTURE 9(8) OCCURS 5.
    03  SEG-4.
        05  SEG-4-A             OCCURS 18.
            07  DATA-4-A                PICTURE S9(9)V9(3) OCCURS 5.
    03  SEG-5.
        05  SEG-5-A.
            07  DATA-5-A                PICTURE 9(8) OCCURS 10.
    03  SEG-6.
        05  SEG-6-A.
            07  DATA-6-A                PICTURE 9(8) OCCURS 3.
        05  SEG-6-B.
            07  DATA-6-B                PICTURE 9(5)V9(3) OCCURS 4.
    03  SEG-7.
        05  SEG-7-A.
            07  DATA-7-A                PICTURE 9(8) OCCURS 10.
    03  SEG-8.
        05  SEG-8-A.
            07  DATA-8-A                PICTURE 9(8) OCCURS 5.
    03  FILLER                          PICTURE X(92).
FD  STATION-MASTER-F
    LABEL RECORD IS OMITTED
    RECORD CONTAINS 80 CHARACTERS
    DATA RECORD IS F-RECORD.
01  F-RECORD.
    03  F-REC                           PICTURE X(80).
WORKING-STORAGE SECTION.
77  I               USAGE COMP      PICTURE 999.
77  J               USAGE COMP      PICTURE 999.
77  TALLY-REC       USAGE COMP      PICTURE 999 VALUE ZERO.
01  F-CONVERTED.
    03  F-SIGNED                PICTURE ---------9.999 OCCURS 5.
01  TALLY-MESSAGE.
    03  TALLY-REC-X                     PICTURE ZZZ9.
    03  FILLER                          PICTURE X(22)
            VALUE " RECORDS CONVERTED".
    03  FILLER                          PICTURE X(105) VALUE SPACES.
PROCEDURE DIVISION.
A000-CONTROL SECTION.
A001.
    NOTE    THIS SECTION CONTROLS EXECUTION
            OF THE PROGRAM.
A010-START.
    OPEN OUTPUT PRINT-FILE.
    OPEN INPUT  STATION-MASTER-C.
    OPEN OUTPUT STATION-MASTER-F.
A030-READ-RECORD.
    READ STATION-MASTER-C
        AT END GO TO A090-STOP.
    PERFORM C000-WRITE-CONVERTED.
    GO TO A030-READ-RECORD.
A090-STOP.
    CLOSE STATION-MASTER-C.
    CLOSE STATION-MASTER-F.
    MOVE TALLY-REC TO TALLY-REC-X.
    MOVE TALLY-MESSAGE TO PRINT-DATA.
    MOVE 1 TO CARRIAGE-CONTROL.
    WRITE PRINT-LINE.
    CLOSE PRINT-FILE.
    STOP RUN.
C000-WRITE-CONVERTED SECTION.
C001.
    NOTE    THIS SECTION CONVERTS THE COBOL RECORD TO FORTRAN
            COMPATIBLE BY BREAKING THE RECORD INTO
            80 CHARACTER BCD RECORDS.
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```
 C010-CONVERT-RECORD.
     MOVE SEG-1 TO F-RECORD.
     WRITE F-RECORD.
     MOVE SEG-2 TO F-RECORD.
     WRITE F-RECORD.
     PERFORM MOVE-SEG-3-A
         VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 6.
     MOVE SEG-3-B TO F-RECORD.
     WRITE F-RECORD.
     PERFORM MOVE-SEG-4-A
         VARYING I FROM 1 BY 1 UNTIL I GREATER THAN 18.
     MOVE SEG-5 TO F-RECORD.
     WRITE F-RECORD.
     MOVE SEG-6 TO F-RECORD.
     WRITE F-RECORD.
     MOVE SEG-7 TO F-RECORD.
     WRITE F-RECORD.
     MOVE SEG-8 TO F-RECORD.
     WRITE F-RECORD.
     ADD 1 TO TALLY-REC.
     GO TO C090-EXIT.
 MOVE-SEG-3-A.
     MOVE SEG-3-A (I) TO F-RECORD.
     WRITE F-RECORD.
 MOVE-SEG-4-A.
     PERFORM MOVE-DATA-4-A
         VARYING J FROM 1 BY 1 UNTIL J GREATER THAN 5.
     MOVE F-CONVERTED TO F-RECORD.
     WRITE F-RECORD.
 MOVE-DATA-4-A.
     MOVE DATA-4-A (I J) TO F-SIGNED (J).
 C090-EXIT.
     EXIT.
&
      PROGRAM CNVRT2 (TAPEX,STNFIL,OUTPUT
     $,         TAPE10=TAPEX,TAPE11=STNFIL,TAPE61=OUTPUT)
C
C  PROGRAM TO CONVERT THE INTERMEDIATE FORTRAN TAPE (BCD)
C    TO THE FINAL REDUCED STATION FILE (BINARY)
C
C  STATION FILE RECORD
C    WORD       DESCRIPTION
C                             DATA IS INTEGER UNLESS OTHERWISE SPECIFIED
C       1  STATION NUMBER
C     2-3  STATE NAME          ALPHA
C     4-5  COUNTY NAME         ALPHA
C     6-7  STREAM NAME         ALPHA
C     8-9  LOCATION NAME       ALPHA
C      10  LATITUDE
C      11  LONGITUDE
C      12  TOTAL
C      13  TOTAL AREA
C      14  MAIN CHANNEL SLOPE             FL. PT.
C      15  RAIN INTENSITY                 FL. PT.
C      16  RAIN EROSION INDEX             FL. PT.
C      17  SLOPE PCT CLASS                FL. PT.
C      18 EROSION CLASS                   FL. PT.
C      19  SOIL INFILTRATION              FL. PT.
C      20  SOIL INDEX                     FL. PT.
C   21-52  SOIL CLASS AREA TABLE (4X8) (4 CLASSES, 8 TYPES)
C   53-84  SOIL RESOURCE GROUPS  (4X8) (4 CLASSES, 8 TYPES)
C      85  DATA YEAR (1969)
C  86-175  WATER QUALITY TABLE (18X5) (18 PARAMETERS, 5 PERIODS)
C               18 PARAMETERS = SEE BELOW
C                5 PERIODS = ANNUAL, SPRING, SUMMER, FALL, WINTER
C          WATER QUALITY PARAMETERS    FLOATING PT.
```

```
C              1  TEMPERATURE (F)
C              2  STREAMFLOW  (CFS)
C              3  TURBIDITY   (JU)
C              4  DO          (MGL)
C              5  BOD         (MGL)
C              6  PHOSPHORUS  (MGL)
C              7  TOTAL COLIFORM (100ML)
C              8  SUSPENDED SOLIDS (MGL)
C              9  DISSOLVED SOLIDS (TAF)
C             10  NITRATE     (MGL)
C             11  HERBICIDE   (TY)
C             12  INSECTICIDE (TY)
C             13  FUNGICIDE   (TY)
C          14-18  NOT USED
C
C       176  LAND AREA
C       177  LAND IN FARMS
C       178  OTHER LAND
C       179  TOTAL CROP AREA
C       180  CROPLAND HARVESTED
C       181  PASTURE + GRAZING
C       182  OTHER CROPLAND
C       183  IRRIGATED
C       184  OTHER FARMLAND
C       185  ROW CROPS
C       186  SMALL GRAIN
C       187  HAY
C       188  WOODLANDS
C   189-192  C-FACTORS (4) (4 CROP GROUPS)     FL. PT.
C       193  CATTLE
C       194  HOGS
C       195  SHEEP
C       196  CHICKENS
C       197  NITROGEN
C       198  PHOSPHATE
C       199  POTASH
C       200  HERBICIDE
C       201  INSECTICIDE
C       202  FUNGICIDE
C   203-207  RAINFALL (ANNUAL,SPRING,SUMMER,FALL,WINTER)
C   208-210  NOT USED
C
      DIMENSION IBUF(210), RAIN(5)
      EQUIVALENCE  (IBUF(203), RAIN(1))
C
      LUBCD  = 10
      LUBIN  = 11
      LUPRNT = 61
      NRECS  = 0
C
C  READ THE 80-CHARACTER BCD RECORDS OF THE NEXT LOGICAL RECORD
C
  100 CONTINUE
      READ (LUBCD,6001) (IBUF(I),I=1,10)
 6001 FORMAT (I8,4(A10,A6),I8)
      IF (EOF(LUBCD)) 500,105
  105 READ (LUBCD,6002) (IBUF(I),I=11,19)
 6002 FORMAT (2I8,7F8.3)
      L = 19
      DO 150 J = 1,6
      K = L + 1
      L = K + 9
      READ (LUBCD,6003) (IBUF(I),I=K,L)
 6003 FORMAT (10I8)
  150 CONTINUE
      READ (LUBCD,6003) (IBUF(I),I=81,85)
      L = 85
      DO 200 J = 1,18
      K = L + 1
      L = K + 4
      READ (LUBCD,6004) (IBUF(I),I=K,L)
 6004 FORMAT (5F14.3)
  200 CONTINUE
      READ (LUBCD,6003) (IBUF(I),I=176,185)
      READ (LUBCD,6005) (IBUF(I),I=186,192)
 6005 FORMAT (3I8,4F8.3)
      READ (LUBCD,6003) (IBUF(I),I=193,202)
      READ (LUBCD,6003) (IBUF(I),I=203,207)
      DO 250 I = 208,210
  250 IBUF(I) = 0
C  CONVERT THE RAINFALL DATA
      ANNUAL = 0.0
      DO 275 I = 1,4
      J = 207 - I
      K = 6 - I
      RAIN(K) = 0.001 * FLOAT( IBUF(J) )
  275 ANNUAL = ANNUAL + RAIN(K)
      RAIN(1) = ANNUAL
C
C  WRITE THE RECORD
C
      BUFFER OUT (LUBIN,1) (IBUF(1),IBUF(210))
      IF (UNIT(LUBIN)) 300,325,330
  300 NRECS = NRECS + 1
      GO TO 100
C         * EOF ON WRITE *
  325 STOP 31
C         * WRITE PARITY *
  330 STOP 32
C
C  END OF JOB
C
  500 ENDFILE LUBIN
      WRITE (LUPRNT,6101) NRECS
 6101 FORMAT (1H1,I4,18H RECORDS CONVERTED )
      STOP
      END
&
#
```

5. SORT FILE INTO 13 SUBBASIN FILES

```
BARRY,CM10000,T20.
ACCOUNT,M350001,MIDWEST,3807C.
GET,TAPE10=BDS3807.
REWIND,BDS3807.
RFL,40000.
RUN23(S)
RFL,70000.
LGO.
SAVE,TAPE11=BES3807.
GET,BES3807.
REWIND,BES3807.
COPYSBF(BES3807,OUTPUT)
GET COST(LIBRARY)
RFL,10000.
COST.
EXIT.
GET COST(LIBRARY)
COST.
&
      PROGRAM SORT (TAPE10,TAPE11,TAPE31,TAPE32,TAPE33,TAPE34,TAPE35,
     1             TAPE36,TAPE37,TAPE38,TAPE39,TAPE40,TAPE41,TAPE42,
     2             TAPE43, INPUT,OUTPUT,TAPE12=INPUT,TAPE13=OUTPUT)
      DIMENSION ISUBS(233),ARAY(80)
C
C---- READ SUB-BASIN CODES
C
      READ (12,5) ISUBS
    5 FORMAT (25I3,5X)
      REWIND 12
      DO 10 I=31,43
      REWIND I
   10 CONTINUE
      IREC=0
C
C---- READ NEXT BASIN CARD
C
   12 IREC = IREC + 1
      READ (10,13) ARAY
      IF (EOF,10) 1000,14
   13 FORMAT (20A4)
   14 ISUB=ISUBS(IREC)
C
C---- WRITE IN PROPER SUB-BASIN FILE
C
      WRITE (ISUB,13) ARAY
      GO TO 12
 1000 DO 1001 I=31,43
      REWIND I
 1001 CONTINUE
      DO 1100 I=31,43
 1050 READ (I,13) ARAY
      IF (EOF,I) 1100,1075
 1075 WRITE (11,13) ARAY
      GO TO 1050
 1100 CONTINUE
      STOP
      END
&
&
*
```

6. ADD ANNUAL RAINFALL TO FILE

```
      PROGRAM CNVRT3 (OLDFIL,NEWFIL,OUTPUT
     $,         TAPE10=OLDFIL,TAPE11=NEWFIL,TAPE61=OUTPUT)
C
C  PROGRAM TO CONVERT RAINFALL DATA ON THE STN. FILE
C
      DIMENSION IBUF(210), READ(5)
C
      LUOLD  = 10
      LUNEW  = 11
      LUPRNT = 61
      NRECS  = 0
C
C  GET OLD RECORD
C
  100 BUFFER IN (LUOLD,1) (IBUF(1),IBUF(210))
      IF (UNIT(LUOLD)) 150,500,125
C         * READ PARITY *
  125 STOP 2010
C
C  CONVERT TO NEW RECORD
C
  150 ANNUAL = 0.0
      DO 175 I = 1,4
      J = 207 - I
      K = 6 - I
      RAIN(K) = 0.001 * FLOAT( IBUF(J) )
  175 ANNUAL = ANNUAL + RAIN(K)
      RAIN(1) = ANNUAL
C
C  WRITE THE NEW RECORD
C
      BUFFER OUT (LUNEW,1) (IBUF(1),IBUF(210))
      IF (UNIT(LUNEW)) 200,225,250
  200 NRECS = NRECS + 1
      GO TO 100
C         * EOF ON WRITE *
  225 STOP 1011
C         * WRITE PARITY *
  250 STOP 2011
C
C  CONVERSION COMPLETE
C
  500 ENDFILE LUNEW
      WRITE (LUPRNT,6101) NRECS
 6101 FORMAT (1H1,I4,18H RECORDS CONVERTED )
      STOP
      END
&
```

7. SAMPLE OF SPSS RUNS

```
BARRY,T150,CM10000.
ACCOUNT,M350001,MIRWEST,3807C.
GET,RES3807.
REWIND,RES3807.
COMMON(MRISPSS)
REWIND,MRISPSS.
RFL,120000.
MRISPSS.
GET,COST(LIBRARY)
RFL,10000.
COST.
&
MRISPSS         3807C
RUN NAME        BASIC STATISTICS, CORRELATION, REGRESSION BY SUB-BASIN
VARIABLE LIST   VAR001 TO VAR036
SUBFILE LIST    S31,S32,S33,S34,S35,S36,S37,S38,S39,S40,S41,S42,S43
INPUT MEDIUM    RES3807
NO. OF CASES    28,41,20,27,32,18,9,9,5,4,5,11,24
INPUT FORMAT    FIXED(F8.0,6F12.3/4F12.3/10F8.0/6F8.0,F8.3/4F8.3,4F8.0)
VAR LABELS      VAR001,STATION/VAR002,STREAMFLOW-CPS/
                VAR003,TURBIDITY-JU/VAR004,DO-MGL/
                VAR005,BOD-MGL/VAR006,PHOSPHOROUS-MGL/
                VAR007,TOTAL COLIFORM-1--100ML/VAR008,
                TOTAL COLIFORM-2--100ML/ VAR009,FILTERED RSD-MGL/
                VAR010,DISSOLVED SOLIDS-TONS PER DAY/
                VAR011,NITRATE-MGL/VAR012,LAND AREA/
                VAR013,LAND IN FARMS/VAR014,TOTAL CROP AREA/
                VAR015,CROPLAND HARVESTED/VAR016,PASTURE AND GRAZING/
                VAR017,OTHER CROPLAND/VAR018,IRRIGATED LAND/
                VAR019,OTHER FARMLAND/VAR020,CATTLE/VAR021,HOGS/
                VAR022,SHEEP/VAR023,CHICKENS/VAR024,NITROGEN/
                VAR025,PHOSPHATE/VAR026,HERBICIDES/VAR027,INSECTISIDES/
                VAR028,ANNUAL RAINFALL/VAR029,RAIN INTENSITY/
                VAR030,SLOPE PCT CLASS/VAR031,EROSION CLASS/
                VAR032,SOIL INFILTRATION/VAR033,ROW CROPS/
                VAR034,SMALL GRAIN/VAR035,HAY/VAR036,WOODLANDS
COMPUTE         VAR037=VAR007 + VAR008
VAR LABELS      VAR037,COLIFORM TOTALS
MISSING VALUES VAR001 TO VAR037(0)
COMPUTE         VAR038=VAR020 + VAR021
COMPUTE         VAR039=(1.0*VAR020)+(.25*VAR021)+(.15*VAR022)+(.015*VAR023)
COMPUTE         VAR048=(1.0*VAR020)+(.09*VAR021)+(.06*VAR022)+(.006*VAR023)
COMPUTE         VAR047=(1.0*VAR020)+(.167*VAR021)+(.067*VAR022)+(.0067*VAR023)
COMPUTE         VAR040 = VAR024 + VAR025
VAR LABELS      VAR038,CATTLE AND HOGS/VAR039,ALL LIVESTOCK/
                VAR040,NITROGEN AND PHOSPHATE
MISSING VALUES VAR038 TO VAR040(0)
COMPUTE         VAR041 =(VAR002 * VAR004) * 5.39
COMPUTE         VAR042 =(VAR002 * VAR005) * 5.39
COMPUTE         VAR043 =(VAR002 * VAR006) * 5.39
COMPUTE         VAR044 =(VAR002 * VAR011) * 5.39
COMPUTE         VAR010 = VAR010
COMPUTE         VAR038 =    (VAR038 / VAR012)
COMPUTE         VAR047=VAR047/VAR012
COMPUTE         VAR048=VAR048/VAR012
COMPUTE         VAR039 =    (VAR039 / VAR012)
COMPUTE         VAR024 =    (VAR024 / VAR012)
COMPUTE         VAR040 =    (VAR040 / VAR012)
COMPUTE         VAR020 =    (VAR020 / VAR012)
COMPUTE         VAR021 =    (VAR021 / VAR012)
COMPUTE         VAR027=VAR027 / VAR012
COMPUTE         VAR016 = VAR016 / VAR012
COMPUTE         VAR025 =    (VAR025 / VAR012)
COMPUTE         VAR018 =    (VAR018 / VAR012)
COMPUTE         VAR014=VAR014/VAR012
VAR LABELS      VAR041,DO-LB-PER-DAY/VAR042,BOD-LB-PER-DAY
                VAR043,P-LB-PER-DAY/VAR044,NO3-LB-PER-DAY
MISSING VALUES VAR041 TO VAR044(0)
COMPUTE         VAR045=(VAR033*.45)+(VAR034*.2)+(VAR035*.02)
COMPUTE         VAR045=VAR045 + (VAR036 *.005)
COMPUTE         VAR045=VAR045/VAR012
COMPUTE         VAR046=(VAR002 * VAR003/VAR012 )
VAR LABELS      VAR045,C FACTOR/VAR046,TURBIDITY-X FLOW
MISSING VALUES VAR045 TO VAR046(0)
COMPUTE         VAR043=VAR043/VAR012
COMPUTE         VAR044=VAR044/VAR012
COMPUTE         VAR042=VAR042/VAR012
COMPUTE         VAR010=VAR010/VAR012
COMPUTE         VAR041=VAR041/VAR012
MISSING VALUES VAR047,VAR048(0)
COMPUTE         VAR050=VAR003/VAR012
COMPUTE         VAR053=LN(VAR050)
COMPUTE         VAR064=LN(VAR014)
COMPUTE         VAR070=LN(VAR020)
COMPUTE         VAR071=LN(VAR021)
COMPUTE         VAR075=LN(VAR025)
COMPUTE         VAR078=LN(VAR028)
COMPUTE         VAR079=LN(VAR029)
COMPUTE         VAR080=LN(VAR030)
COMPUTE         VAR082=LN(VAR032)
COMPUTE         VAR095=LN(VAR045)
MISSING VALUES VAR050,VAR053,VAR064,VAR070,VAR071,VAR075,VAR078,VAR080,VAR082,
                VAR095,VAR079(0)
VAR LABELS      VAR050,TURB-PER-SQ-MI/VAR053,TURB-PER-SQ-MI/VAR064,LOG-CROPLAND
                PER SQ MI/VAR070,LOG-CATTLE-PER-SQ-MILE/VAR071,LOG-HOGS-PER-SQ-MI
                LE/VAR075,LOG-PHOS-PER-SQ-MI/VAR078,LOG-RAINFALL/VAR079,LOG-RAINF
                ALL INTENSITY/VAR080,LOG-SLOPE-PCT-CLASS/VAR082,LOG-SOIL INFILTRA
                TRATION RATE/VAR095,LOG-C FACTOR/
COMPUTE         VAR096=LN(VAR046)
MISSING VALUES VAR096(0)
COMPUTE         VAR066=LN(VAR016)
COMPUTE         VAR068=LN(VAR018)
COMPUTE         VAR074=LN(VAR024)
COMPUTE         VAR094=LN(VAR044)
COMPUTE         VAR097=LN(VAR047)
COMPUTE         VAR092=LN(VAR042)
COMPUTE         VAR089=LN(VAR039)
MISSING VALUES VAR066,VAR068,VAR074,VAR094,VAR097,VAR092,VAR089(0)
VAR LABELS      VAR068,LOG-PASTURE-PER-SQ-MI/VAR066,LOG-IRRIGATED-PER-SQ-MI/
                VAR074,LOG-NITROGEN-PER-SQ-MI/VAR094,LOG-NITRATE-PPD-PER-SQ-MI/
                VAR097,LOG-LIVESTOCK-PER-SQ-MI/VAR092,LOG-BOD-PPD-PER-SQ-MI/
                VAR089,LOG-LIVESTOCK-PER-SQ-MI/VAR096,LOG-TURBIDITY-X-FLOW-PER-SQ
                -MI
REGRESSION      VARIABLES=VAR096,VAR064,VAR070,VAR071,VAR075,VAR078,VAR080,VAR082
                   VAR095/
                REGRESSION=VAR096 WITH VAR064 TO VAR095(3)
STATISTICS      8,9
READ INPUT DATA
REGRESSION      VARIABLES=VAR092,VAR064,VAR068,VAR078,VAR070,VAR071,
                VAR095/
                REGRESSION=VAR092 WITH VAR064 TO VAR095(3)
REGRESSION      VARIABLES=VAR094,VAR070,VAR071,        VAR064,VAR066,VAR068,
                VAR078,VAR074,VAR095/
                REGRESSION=VAR094 WITH VAR070 TO VAR095(3)
FACTOR          VARIABLES=VAR064,VAR070,VAR071,VAR075,VAR078,VAR080,VAR082,
                VAR095/
STATISTICS      4,5,6,7,8
FACTOR          VARIABLES=VAR064,VAR068,VAR078,VAR070,VAR071,        VAR095/
STATISTICS      4,5,6,7,8
FACTOR          VARIABLES=VAR070,VAR071,        VAR064,VAR066,VAR068,VAR078,
                VAR074,VAR095/
STATISTICS      4,5,6,7,8
FINISH
&
*
```

8. USE FILE TO GET TABLES SHOWING COEFFICIENT OF VARIATION BETWEEN PREDICTED AND OBSERVED VALUES OF DEPENDENT VARIABLES

```
BARRY,CM60000,T100.
ACCOUNT,M350001,MIRWEST,3807C.
GET,TAPE3=BES3807.
REWIND,TAPE3.
FTN,R=2.
MAP.
LGO.
GET,COST(LIBRARY)
RFL,10000.
COST.
EXIT.
GET,COST(LIBRARY)
RFL,10000.
COST.
&
      PROGRAM COMPARE(TAPE3,INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT)
      DIMENSION COEFF(3,11),ISUBS(13),AVGES(3,14,13),YBAR(14,3),COV(14,3),
     1),VALS(17),ICOUNT(3,14),SIGN(3,11),BASIN(14),TEMP(13)
      DIMENSION DEPVAR(3)
      DATA PLUS/1H+/
      DATA PMINUS/1H-/
      DATA ISUBS/28,41,20,27,32,18,9,9,5,4,5,11,24/
      DATA BASIN(1) /9H    31      /
      DATA BASIN(2) /9H    32      /
      DATA BASIN(3) /9H    33      /
      DATA BASIN(4) /9H    34      /
      DATA BASIN(5) /9H    35      /
      DATA BASIN(6) /9H    36      /
      DATA BASIN(7) /9H    37      /
      DATA BASIN(8) /9H    38      /
      DATA BASIN(9) /9H    39      /
      DATA BASIN(10)/9H    40      /
      DATA BASIN(11)/9H    41      /
      DATA BASIN(12)/9H    42      /
      DATA BASIN(13)/9H    43      /
      DATA BASIN(14)/9H    ALL     /
      DATA DEPVAR(1)/10HTUR-X-FLOW/
      DATA DEPVAR(2)/10HBOD-PPD/M2/
      DATA DEPVAR(3)/10HNIT-PPD/M2/
C
C---- INITIALIZE ARRAYS
C
      DO 2 I=1,14
      DO 29 J=1,3
      ICOUNT(J,I)=0
      YBAR(I,J)=0.0
      COV(I,J)=0.0
   29 CONTINUE
      DO 11 K=1,3
      DO 1 J=1,13
      AVGES(K,I,J)=0.0
    1 CONTINUE
   11 CONTINUE
    2 CONTINUE
C
C---- READ COEFFICIENTS
C
      DO 3 I=1,11
      READ (1,101) (COEFF(J,I),J=1,3)
  101 FORMAT(3F15.5)
```

```
    3 CONTINUE
C
C---- BEGIN LOOP TO READ SUB-BASIN VALUES
C
      DO 5 I=1,13
      J=ISUBS(I)
      DO 4 K=1,J
      READ (3,102)(VALS(L),L=1,17)
  102 FORMAT(8X,2F12.3,12X,F12.3/36X,F12.3/4(F8.0,8X),2F8.0/16X,2F8.0,
     116X,F8.3/8X,F8.3,16X,4F8.0)
      DO 19 N=4,10
      IF(VALS(5) .EQ. 0.0) GO TO 6
      N2=N+2
      TEMP(N)=VALS(N2)/VALS(5)
      GO TO 19
    6 TEMP(N)=0.0
   19 CONTINUE
      TEMP(11)=VALS(13)
      TEMP(12)=VALS(14)
      IF(VALS(5) .EQ. 0.0) GO TO 10
      TEMP(13)=(VALS(15)*.45 +VALS(16)*.2 +VALS(17)*.02 +VALS(18)*.005)
     1/VALS(5)
      TEMP(1)=VALS(1)*VALS(2)/VALS(5)
      TEMP(2)=VALS(1)*VALS(3)*5.34/VALS(5)
      TEMP(3)=VALS(1)*VALS(4)*5.34/VALS(5)
      GO TO 18
   10 TEMP(1)=0.0
      TEMP(2)=0.0
      TEMP(3)=0.0
      TEMP(13)=0.0
   18 DO 23 L=1,3
      IF(TEMP(L) .EQ. 0.0) GO TO 23
      DO 20 N=4,13
      NI=N-2
      IF(TEMP(N) .EQ. 0.0 .AND. COEFF(L,NI) .NE. 0.0) GO TO 30
   20 CONTINUE
      AVGES(L,I,L)=AVGES(L,I,L)+ALOG(TEMP(L))
      AVGES(L,14,L)=AVGES(L,14,L)+ALOG(TEMP(L))
      DO 21 N=4,13
      AVGES(L,I,N)=AVGES(L,I,N)+ALOG(TEMP(N))
      AVGES(L,14,N)=AVGES(L,14,N)+ALOG(TEMP(N))
   21 CONTINUE
      ICOUNT(L,I)=ICOUNT(L,I) + 1
      ICOUNT(L,14)=ICOUNT(L,14) + 1
   30 CONTINUE
   23 CONTINUE
    4 CONTINUE
C
C---- COMPUTE AVERAGES
C
      DO 24 N=1,3
      DO 7 L=1,13
      IF(ICOUNT(N,I) .EQ. 0) GO TO 71
      DIV=ICOUNT(N,I)
      AVGES(N,I,L)=AVGES(N,I,L)/DIV
      GO TO 7
   71 AVGES(N,I,L)=0.0
    7 CONTINUE
   24 CONTINUE
C
C---- COMPUTE COEFFICIENT OF VARIATION
C
      DO 8 L=1,3
      YBAR(I,L)=COEFF(L,1)+COEFF(L,2)*AVGES(L,I,4)+COEFF(L,3)*AVGES(L,I,5
     1S)+COEFF(L,4)*AVGES(L,I,6)+COEFF(L,5)*AVGES(L,I,7)+COEFF(L,6)*AVGES
     2S(L,I,8)+COEFF(L,7)*AVGES(L,I,9)+COEFF(L,8)*AVGES(L,I,10)+COEFF(L,9
     39)*AVGES(L,I,11)+COEFF(L,10)*AVGES(L,I,12)+COEFF(L,11)*AVGES(L,I,13
     43)
      IF(YBAR(I,L) .EQ. 0.0) GO TO 22
      COV(I,L)=((YBAR(I,L)-AVGES(L,I,L))/YBAR(I,L))*100.0
      COV(I,L)=ABS(COV(I,L))
      GO TO 8
   22 COV(I,L)=100.0
    8 CONTINUE
    5 CONTINUE
C
C---- COMPUTE COEFFICIENT OF VARIATION FOR ALL SUBBASINS
C
      DO 209 N=1,3
      AVGES(N,14,N)=AVGES(N,14,N)/ICOUNT(N,14)
      DO 207 L=4,13
      AVGES(N,14,L)=AVGES(N,14,L)/ICOUNT(N,14)
  207 CONTINUE
  209 CONTINUE
      DO 208 L=1,3
      YBAR(14,L)=COEFF(L,1)+COEFF(L,2)*AVGES(L,14,4)+COEFF(L,3)*AVGES(L,
     114,5)+COEFF(L,4)*AVGES(L,14,6)+COEFF(L,5)*AVGES(L,14,7)+COEFF(L,6)
     2*AVGES(L,14,8)+COEFF(L,7)*AVGES(L,14,9)+COEFF(L,8)*AVGES(L,14,10)+
     3COEFF(L,9)*AVGES(L,14,11)+COEFF(L,10)*AVGES(L,14,12)+COEFF(L,11)*A
     4VGES(L,14,13)
      COV(14,L)=((YBAR(14,L)-AVGES(L,14,L))/YBAR(14,L))*100.0
      COV(14,L)=ABS(COV(14,L))
  208 CONTINUE
C
C**** PRINT VALUES
C
      DO 9 I=1,3
C
C---- STORE SIGN OF EACH COEFFICIENT AND MAKE POSITIVE FOR PRINTING EQUATION
C
      DO 31 J=1,11
      SIGN(I,J)=PLUS
      IF(COEFF(I,J).LT. 0.0) SIGN(I,J)=PMINUS
   31 COEFF(I,J)=ABS(COEFF(I,J))
C
C---- PRINT EXPLANATION AND EQUATION
C
      WRITE(2,103)
  103 FORMAT(1H1,23HPREDICTIVE EQUATION IS:        )
      WRITE(2,104) I,(SIGN(I,J),COEFF(I,J),J=1,11)
  104  FORMAT(1H ,5HLN(Y(,I1,4H))= ,A1,F8.5,1X,A1,F8.5,8H*LN(X1) ,A1,
     1F8.5,8H*LN(X2) ,A1,F8.5,8H*LN(X3) ,A1,F8.5,8H*LN(X4) ,A1,F8.5,8H*L
     2N(X5) /20X,A1,F8.5,8H*LN(X6) ,A1,F8.5,8H*LN(X7) ,A1,F8.5,8H*LN(X8) ,A1,F8.
     3 ,A1,F8.5,8H*LN(X9) ,A1,F8.5,8H*LN(X10))
      WRITE(2,105) I,DEPVAR(I),I,DEPVAR(I)
  105 FORMAT(/,9H WHERE Y(,I1,22H)= OBSERVED VALUE OF  ,A10
     1,       /,12H        YBAR(,I1,21H)=PREDICTED VALUE OF ,A10
     2,       /,30H        X(1)=CROPLAND/SQ MILE
     3,       /,32H        X(2)=PASTURE LAND/SQ MILE
     4,       /,37H        X(3)=IRRIGATED LAND/SQ MILE
     5,       /,30H        X(4)=CATTLE/SQ MILE
     6,       /,30H        X(5)=HOGS/SQ MILE
     7,       /,30H        X(6)=NITROGEN/SQ MILE
     8,       /,32H        X(7)=PHOSPHATE/SQ MILE
     9,       /,30H        X(8)=RAINFALL
     A,       /,30H        X(9)=SLOPE-PCT-CLASS
     B,       /,30H        X(10)=C FACTOR
     C,///55H COEFFICIENT OF VARIATION= ABS(YBAR - Y(1))    *  100.0
     D,/31X,11H-----------
     E,/,34X,4HYBAR       )
C
C---- WRITE NEW PAGE HEADING
```

```
C
      WRITE(2,107)
      WRITE(2,106) I,I
  107 FORMAT(1H ,117X,15HNO OF  COEFF OF)
  106 FORMAT(104H BASIN NO.  X(1)      X(2)      X(3)      X(4)      X(5)
     1  X(6)      X(7)      X(8)      X(9)     X(10)      Y(,I1,9H)    YBAR(,
     2I1,17H)  OBS   VAR.PCT.)
C
C---- WRITE COEFFICIRNTS
C
      DO 41 J=1,14
      WRITE(2,108) BASIN(J),(AVGES(I,J,K),K=4,13),AVGES(I,J,I),YBAR(J,I),
     1,ICOUNT(I,J),COV(J,I)
  108 FORMAT(/,A9,12F9.5,I4,F10.2)
   41 CONTINUE
    9 CONTINUE
      STOP
      END
&
 -8.63206        -.80188         -11.17613
-4.47193         -2.31428        -1.88129
  0.0            0.0             -.21286
0.0              0.03081         -.0791
2.53051          -.25308         1.82359
.23789           -.18659         -.19982
0.0              0.0             .62432
.72239           0.0             0.0
-1.10095         2.58872         1.17815
1.2993           0.0             0.0
0.43524          1.74135         .62061
&
#
```

9. PRINT TABLES OF INDEPENDENT VERSUS DEPENDENT VARIABLES GIVING CORRELATION AND REGRESSION ANALYSIS

```
SUMMARY,T100,CM10000.
ACCOUNT,M350415,MIRWEST,3807C.
RFL,50000.
FTN.
COMMON,RJP3807.
REWIND,RJP3807.
REWIND,THL3807.
COMMON,THL3807.
RFL,70000.
LGO(RJP3807,,THL3807)
REWIND,THL3807.
COPYBF(THL3807,OUTPUT)
GET,COST(LIBRARY)
RFL,10000.
COST.
EXIT.
REWIND,THL3807.
COPYBF(THL3807,OUTPUT)
GET,COST(LIBRARY)
RFL,10000.
COST.
&
      PROGRAM SUMMARY (LSTFIL,INPUT,OUTPUT
     $,                   TAPE20=LSTFIL,TAPE60=INPUT,TAPE61=OUTPUT)
C
C  PROGRAM TO READ A COPY OF THE OUTPUT FILE FROM A SPECIAL SPSS
C    RUN WHICH INCLUDES MARGINALS, PEARSON CORRELATIONS, AND REGRESSIONS
C    AGAINST THE SUB-BASIN SEQUENCED STATION DATA FILE
C
C
C  DEFINITIONS OF VARIABLES
C
C    LINE   = LINE IMAGE BUFFER FOR ONE LINE FROM THE LIST FILE
C    IVPTR  = VARIABLE POINTER TABLE, ENTRY GIVES INDEX OF VARIABLE
C                 IN REDUCED SET FOR THIS PROGRAM
C    IVNAM  = 10-CHARACTER NAMES OF VARIABLES IN REDUCED SET
C    IMARG  = MARGINALS STATISTICS TABLE  (14X13X3)
C                 14 SUB-BASINS (31-43, ALL)
C                 13 VARIABLES  (33-36,10,20-21,30-31,24-25,32,18)
C                  3 STATISTICS (MEAN, NO. OBS, STD DEV)
C    ICORR  = CORRELATIONS STATISTICS TABLE  (14X40X3)
C                 14 SUB-BASINS  (31-43, ALL)
C                 40 CORRELATIONS (5 DEPENDENT X 8 INDEPENDENT)
C                  3 STATISTICS   (COEFF., SIG, NO. PAIRS)
C    IREGR  = REGRESSIONS STATISTICS TABLE  (14X40X6)
C                 14 SUB-BASINS  (31-43, ALL)
C                 40 REGRESSIONS (5 DEPENDENT X 8 INDEPENDENT)
C                  3 STATISTICS  (A, B, F) (A TAKES 2 LOCATIONS)
C                     AND TWO DEGREES OF FREEDOM
C
      COMMON /B1/ LINE(14), LUNLST, LUSLST, LXSUB, IXSUB
C
      DIMENSION   IVPTR(48), KEYS1(4), IMARG(14,15,3), JMARG(3)
     $,           ICORR(14,48,3), IREGR(14,48,6)
     $,           IVNAM(14), IHEAD(2)
      DIMENSION IVPTS(48)
C
      EQUIVALENCE (LINE(1), IWORD1)
C
      DATA  LUNLST/20/, LUNCRD/60/, LUNPRT/61/
```

```
C
      DATA IVPTR/   0,0,5,0,0,0,0,0,0,4,
     $              0,0,0,14,0,0,0,15,0,7,
     $              8,0,0,12,13,0,0,16,0,0,
     $              0,0,0,0,0,0,0,0,9,0,
     $              6,1,2,3,0,0,10,11      /
      DATA IVPTS / 0,0,5,0,0,0,0,0,0,4,
     $             0,0,0,12,0,0,0,13,0,7,
     $             8,0,0,10,11,0,0,14,0,0,
     $             0,0,0,0,0,0,0,0,9,0,
     $             6,1,2,3,0,0,9,9          /
C
      DATA (((IREGN(I,J,K),K=1,6),I=1,14),J=1,48) /672*(10H      ****,
     $3H   ,7H   ****,7H   ****,3H***,3H***)/
C
      DATA  KEYS1/ 10HVARIABLE  ,10HMEAN      ,10HSTD DEV
     $,            10HVALID   OB  /
C
      DATA  IMARG/672*1H /, ICORR/2016*1H /
      DATA IVNAM/  10HBOD-PPD/M2,10HP-PPD/M2  ,10HNO3-PPD/M2
     $,            10HCS-TPD/M2 ,10HTUR/M2    ,10HDO-PPD/M2
     $,            10HCAT/SQ MI ,10HHOGS/SQ MI,10HLVSTK/SQMI
     $,            10HNITRO/SQMI,10HPHOS/SQ MI,10HCROP/SQ MI
     $,            10HIRRI/SQ MI,10HRAINFALL        /
C
C                       * * * * * * * * * * *
C                   ***** MARGINALS SECTION *****
C                       * * * * * * * * * * *
C
C  TOP OF LOOP BY  STATISTIC
C
      LXSUB = 0
      IXSUB = 0
  150 DO 300 IXSTAT = 1,4
C
C  GET NEXT LINE IMAGE
  200 CALL GETLIN
      IF (IXSUB - LXSUB) 600,210,205
  205 LXSUB = IXSUB
C
C  BRANCH ACCORDING TO LINE CONTENT
  210 IF (IWORD1.NE.KEYS1(IXSTAT)) GO TO 200
      GO TO (220,240,260,280),IXSTAT
C
C  DECODE VARIABLE NUMBER
  220 DECODE ( 17,5101,LINE) JXVAR
 5101 FORMAT (14X,I3)
      KXVAR = IVPTR(JXVAR)
C
C  CHECK IF VARIABLE IS NEEDED
      IF (KXVAR.LE.0) GO TO 400
      GO TO 300
C
C  DECODE MEAN
  240 DECODE ( 22,5102,LINE) IMARG(IXSUB,KXVAR,1)
 5102 FORMAT (12X,A10)
      GO TO 300
C
C  DECODE STD DEV
  260 DECODE ( 22,5102,LINE) IMARG(IXSUB,KXVAR,3)
      GO TO 300
C
C  DECODE NO. VALID OBS.
  280 DECODE ( 31,5103,LINE) IMARG(IXSUB,KXVAR,2)
 5103 FORMAT (23X,A8)
C
```

```
C  END OF STATISTICS LOOP
  300      CONTINUE
C
C  CONTINUE SCAN OF MARGINALS
  400 GO TO 150
C
C  OVERRIDE SUB-BASIN STATISTICS
  600 KXSUB = 0
  620 READ (LUNCRD,6001) JXSUB, JXVAR, (JMARG(I),I=1,3)
 6001 FORMAT (I3,I2,5X,A10,5X,A10,2X,A8)
      LUSCRD = IXEOF(LUNCRD)
      IF (LUSCRD.EQ.1) GO TO 800
      IF (JXSUB.EQ.999) GO TO 800
      IF (JXSUB.EQ.0) GO TO 640
      KXSUB = JXSUB
      GO TO 620
  640 KXVAR = IVPTR(JXVAR)
      IF (KXVAR.LE.0) GO TO 620
      IMARG(KXSUB,KXVAR,1) = JMARG(1)
      IMARG(KXSUB,KXVAR,2) = JMARG(3)
      IMARG(KXSUB,KXVAR,3) = JMARG(2)
      GO TO 620
C
C                       * * * * * * * * * * * *
C                  ***** CORRELATION SECTION *****
C                       * * * * * * * * * * * *
C
C  TOP OF LOOP FOR ROWS
  800 LXSUB = IXSUB
  810   LXCOMB = 0
C
  815    IXCOMB = LXCOMB + 1
         LXCOMB = IXCOMB + 5
      IF(LXCOMB.GT.8.AND.LXCOMB.LT.14)LXCOMB=8
      IF(LXCOMB.GT.24.AND.LXCOMB.LT.30)LXCOMB=24
      IF (LXCOMB.GT.48)LXCOMB = 48
C
C  LOOK FOR FIRST LINE OF NEXT ROW
  850 CALL GETLIN
      IF (IXSUB - LXSUB) 1400,870,860
  860 LXSUB = IXSUB
  870 DECODE (4,5201,LINE) IDATA
 5201 FORMAT (A4)
      IF (IDATA.NE.4HVAR0) GO TO 850
C
C  DECODE COEFFICIENTS
      DECODE (120,5202,LINE) (ICORR(IXSUB,I,1),I=IXCOMB,LXCOMB)
 5202 FORMAT (6(10X,A7,3X))
C
C  READ NUMBERS OF PAIRS
      READ (LUNLST,5203) (ICORR(IXSUB,I,3),I=IXCOMB,LXCOMB)
 5203 FORMAT (6(12X,A5,3X))
C
C  READ SIGNIFICANCE LEVELS
      READ (LUNLST,5204) (ICORR(IXSUB,I,2),I=IXCOMB,LXCOMB)
 5204 FORMAT (6(13X,A5,2X))
      DO 1050 I = IXCOMB,LXCOMB
      IF (ICORR(IXSUB,I,2).EQ.5H ****) ICORR(IXSUB,I,1) = 7H    ****
 1050 CONTINUE
C
C  END OF ROW LOOP
      IF (LXCOMB .GE. 48) GO TO 810
      GO TO 815
C
C
C                       * * * * * * * * * * * *
```

```
                            ***** REGRESSIONS SECTION *****
C                                 * * * * * * * * * * * *
C
C
C  TOP OF REGRESSION SCAN LOOP
 1400 LXSUB = IXSUB
C
C  LOOK FOR DEPENDENT VARIABLE
 1450 CALL GETLIN
      IF (LUSLST.EQ.1) GO TO 2000
      IF (IXSUB - LXSUB) 1460,1470,1460
 1460 LXSUB = IXSUB
 1470 IF (IWORD1.NE.10HDEPENDENT ) GO TO 1450
      DECODE (30,5305,LINE) IXDEP
 5305 FORMAT (27X,I3)
C
C      LOOK FOR LINE WITH DEGREE OF FREEDOM
C
 1475 CALL GETLIN
      IF (IWORD1.NE.10HR SQUARE   ) GO TO 1475
      DECODE(75,5301,LINE) IDF1
 5301 FORMAT(72X,A3)
      READ(LUNLST,5306) IDF2
 5306 FORMAT(73X,A3)
C
C  LOOK FOR LINE WITH VARIABLE INDEX, B, AND F
 1480 CALL GETLIN
      DECODE ( 4,5302,LINE) IDATA
 5302 FORMAT (A4)
      IF (IDATA.NE.4HVAR0) GO TO 1480
C
C  GET VARIABLE INDEX, B, F
      DECODE (70,5303,LINE) IXIND, IDATA1, IDATA2
 5303 FORMAT (4X,I2,10X,A10,34X,A10)
      IF (IDATA2.EQ.10H          B) IDATA2 = 7H   ****
      IXDEP = IVPTS(IXDEP)
      IXIND = IVPTS(IXIND)
      IXCOMB = 8*(IXDEP - 1) + (IXIND - 8)
      IREGR(IXSUB,IXCOMB,3)= IDATA1
      IREGR(IXSUB,IXCOMB,4)= IDATA2
      IREGR(IXSUB,IXCOMB,5)= IDF1
      IREGR(IXSUB,IXCOMB,6)= IDF2
C
C  GET CONSTANT (A)
      READ (LUNLST,5304) (IREGR(IXSUB,IXCOMB,I), I=1,2)
 5304 FORMAT (14X,A10,A3)
C
C  CONTINUE LOOKING FOR REGRESSIONS
      GO TO 1450
C
C                                * * * * * * * * * *
C                           ***** PRINT SECTION *****
C                                * * * * * * * * * *
C
C
C  TOP OF LOOP BY SUB-BASIN
 2000 DO 2400 IXSUB = 1,14
C
C  PREPARE HEADING WITH SUB-BASIN LABEL
      IF (IXSUB.LT.14) GO TO 2020
      IHEAD(1) = 10HALL SUB-BA
      IHEAD(2) =  4HSINS
      GO TO 2030
 2020 ISUB = IXSUB + 30
      ENCODE (20,5501,IHEAD) ISUB
 5501 FORMAT (10HSUB-BASIN ,I2,8X)
C
C  PRINT NEW PAGE HEADING
```

```
 2030 WRITE (LUNPRT.6101) (IHEAD(I).I=1.2)
 6101 FORMAT (1H1.38X.40HREGRESSION AND CORRELATION ANALYSIS FOR .2A10
     $//58H  DEPENDENT     INDEPENDENT   CORRELATION  SIGNIFICANC
     $. 6HNO. OF .15X.42H           STANDARD   REGRESSION EQUATION
     $.10HREGRESSION /45H  VARIABLE       VARIABLE     COEFFICIENT
     $.57HLEVEL                              MEAN      OBS.   DEVIATION
     $.30HY = A . BX          SIGNIFICANCE
     $//6X.1HY.13X.1HX.13X.1HR.6X.2HDF.41X.1HA.9X.1HB.11X.1HF)
C
C  TOP OF LOOP BY DEPENDENT VARIABLE
 2050 DO 2300 IXDEP = 1.5
C
C  PRINT DEPENDENT VARIABLE LINE
      WRITE (LUNPRT.6102) IVNAM(IXDEP).(IMARG(IXSUB.IXDEP.I).I=1.3)
 6102 FORMAT (/2X.A10.54X.A10.A8.2X.A10/)
C
C  TOP OF LOOP BY INDEPENDENT VARIABLE
      DO 2200 IXIND = 7.14
C
C      DETERMINE WHICH DEPENDENT VARIABLES IS USED
C
      IXIND2=IXIND
      IF(IXDEP.EQ.1.AND.IXIND.GE.10)GO TO 2204
      IF(IXDEP.EQ.2.OR.IXDEP.EQ.3)GO TO 2205
      IF(IXDEP.GE.4) GO TO 2206
      GO TO 2210
 2205 IF(IXIND.EQ.9) IXIND2=10
      IF(IXIND.GE.10)IXIND2=IXIND.2
      GO TO 2210
 2204 IXIND2=IXIND.2
      GO TO 2210
 2206 IF(IXIND.GE.9) IXIND2=IXIND.2
      GO TO 2210
C
C  PRINT INDEPENDENT VARIABLE LINE
 2210 IXCOMB = 8*(IXDEP - 1) . (IXIND - 6)
      WRITE (LUNPRT.6103) IVNAM(IXIND).(ICORR(IXSUB.IXCOMB.I).I=1.3)
     $.       (IREGR(IXSUB.IXCOMB.I).I=5.6)
     $.    (IMARG(IXSUB.IXIND2.I).I=1.3).(IREGR(IXSUB.IXCOMB.I).I=1.4)
 6103 FORMAT(15X.A10.5X.A7.8X.A5.A5.2X.A3.1H..A3.2X.A10.A8.2X.A10
     $.                    1X.A10.A3.A10.2X.A10)
C
C  BOTTOM OF INDEPENDENT VARIABLE LOOP
 2200 CONTINUE
C
C  BOTTOM OF DEPENDENT VARIABLE LOOP
 2300 CONTINUE
 9030 WRITE (LUNPRT.6101) (IHEAD(I).I=1.2)
      IXDEP=6
      WRITE (LUNPRT.6102) IVNAM(IXDEP).(IMARG(IXSUB.IXDEP.I).I=1.3)
      DO 9200 IXIND = 7.14
C
C      DETERMINE WHICH DEPENDENT VARIABLES IS USED
C
      IXIND2=IXIND
      IF(IXIND.GE.9) IXIND2=IXIND.2
C
C  PRINT INDEPENDENT VARIABLE LINE
      IXCOMB = 8*(IXDEP - 1) . (IXIND - 6)
      WRITE (LUNPRT.6103) IVNAM(IXIND).(ICORR(IXSUB.IXCOMB.I).I=1.3)
     $.       (IREGR(IXSUB.IXCOMB.I).I=5.6)
     $.    (IMARG(IXSUB.IXIND2.I).I=1.3).(IREGR(IXSUB.IXCOMB.I).I=1.4)
C
C  BOTTOM OF INDEPENDENT VARIABLE LOOP
 9200 CONTINUE
C
```

```
C  BOTTOM OF SUB-BASINS LOOP
 2400 CONTINUE
      STOP
      END
      SUBROUTINE GETLIN
C
C  ROUTINE TO GET THE NEXT LINE IMAGE INTO A DECODABLE BUFFER
C
      COMMON /B1/ LINE(14), LUNLST, LUSLST, LXSUB, IXSUB
C
      READ (LUNLST,5001) LINE
 5001 FORMAT (1X,13A10,A2)
      LUSLST = IXEOF(LUNLST)
      IF (LINE(1).NE.7HSUBFILE) GO TO 100
C
      DECODE (24,5111,LINE) ISUB1,ISUB2
 5111 FORMAT (11X,I2,9X,I2)
      IXSUB = ISUB1 - 30
      IF (ISUB2.NE.0) IXSUB = 14
C
  100 RETURN
      END
      FUNCTION IXEOF (LUN)
C
C  FUNCTION TO TEST FOR END OF FILE CONDITION AND RETURN
C     A STATUS CODE   (0=OK, 1=EOF)
C
      IF (EOF(LUN)) 200,100
C
C * NORMAL STATUS -- I/O COMPLETED OK *
  100 IXEOF = 0
      GO TO 9000
C
C * END OF FILE STATUS *
  200 IXEOF = 1
C
 9000 RETURN
      END
&
999
&
#
```

10. PROGRAM TO LIST TABLES OF STATIONS WITH VALID OBSERVATIONS FOR VARIABLES BEING ANALYZED

```
SUMMARY,T150,CM40000.
ACCOUNT,M350001,MIRWEST,3807C.
GET,TAPE10=RES3807.
FTN.
RFL,145000.
LGO.
GET,COST(LIBRARY)
RFL,10000.
COST.
EXIT.
GET,COST(LIBRARY)
RFL,10000.
COST.
^
      PROGRAM SBASIN (TAPE31,TAPE32,TAPE33,TAPE34,TAPE35,TAPE36,TAPE37
     $,              TAPE38,TAPE39,TAPE40,TAPE41,TAPE42,TAPE43,TAPE11
     $, TAPE51,TAPE52,TAPE10,INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT)
C
C  PROGRAM TO CREATE A SUB-BASIN GROUPED STATION DATA FILE
C    FROM THE STATION-NUMBER SEQUENCED STATION DATA FILE
C
      DIMENSION ISUBS(233),VAR(87)
      DATA  LUNCRD/60/, LUNPRT/61/, LUNBAS/10/, LUNSTN/11/
C
C  POSITION FILES
      REWIND LUNBAS
      DO 50 LUNSUB = 31,43
      REWIND LUNSUB
   50 CONTINUE
C
C  READ SUB-BASIN CODES
      DO 1 I=1,28
      ISUBS(I)=1
    1 CONTINUE
      DO 2 I=29,69
      ISUBS(I)=2
    2 CONTINUE
      DO 3 I=70,89
      ISUBS(I)=3
    3 CONTINUE
      DO 4 I=90,116
      ISUBS(I)=4
    4 CONTINUE
      DO 5 I=117,148
      ISUBS(I)=5
    5 CONTINUE
      DO 6 I=149,166
      ISUBS(I)=6
    6 CONTINUE
      DO 7 I=167,175
      ISUBS(I)=7
    7 CONTINUE
      DO 8 I=176,184
      ISUBS(I)=8
    8 CONTINUE
      DO 9 I=185,189
      ISUBS(I)=9
    9 CONTINUE
      DO 10 I=190,193
      ISUBS(I)=10
   10 CONTINUE
         DO 11 I=194,198
         ISUBS(I)=11
   11 CONTINUE
         DO 12 I=199,209
         ISUBS(I)=12
   12 CONTINUE
         DO 13 I=210,233
         ISUBS(I)=13
   13 CONTINUE
C
C  INITIALIZATION
        IREC = 0
        WRITE(LUNPRT,6100)
 6100 FORMAT (1H1)
C
C  READ NEXT BASIN RECORD
  100 IREC = IREC + 1
        READ (LUNBAS,6200) (VAR(I),I=1,36)
        IF(EOF(LUNBAS))200,101
 6200 FORMAT (F8.0,F12.3/4F12.3/10F8.0/8F8.0,F8.3/4F8.3,4F8.0)
  101 DO 121 K=13,27
        IF(VAR(12) .EQ. 0.0) GO TO 122
        VAR(K)=VAR(K)/VAR(12)
        GO TO 121
  122 VAR(K)=0.0
  121 CONTINUE
        VAR(37)=VAR(7) +VAR(8)
        VAR(38)=VAR(20) + VAR(21)
        VAR(39)=VAR(20) +VAR(21) + VAR(22) + VAR(23)
        VAR(40) =VAR(24) + VAR(25)
        VAR(41)=VAR(2) * VAR(4) * 5.34 /VAR(12)
        VAR(42) = VAR(2) *VAR(5) * 5.34/VAR(12)
        VAR(43) =VAR(2) * VAR(6) *5.34  /VAR(12)
        VAR(44)=VAR(2)*VAR(11) *5.34    /VAR(12)
        VAR(3)=VAR(3)/VAR(12)
        VAR(10)=VAR(10)/VAR(12)
C
C---- CONVERT TO  NATURAL LOGS
C
        DO 130 I=45,87
        I1=I-43
        X=VAR(I1)
        VAR(I)=ALOG(VAR(I1))
        IF (X .EQ. 0.0) VAR(I)=0.0
  130 CONTINUE
C
C  DETERMINE SUB-BASIN CODE
  120 ISUB = ISUBS(IREC) + 30
        IF (ISUB.LE.0) GO TO 100
C
C  WRITE RECORD TO PROPER SUB-BASIN FILE
        WRITE(ISUB,6201)VAR
 6201 FORMAT(6F12.3)
        GO TO 100
C
C  PRINT TABLES FOR EACH SUB-BASIN
  200 DO 300 ISUB = 31,43
        REWIND ISUB
        CALL STN(ISUB)
  300 CONTINUE
C
C  RECOMBINE SUB-BASIN FILES INTO ONE STATION FILE
        REWIND LUNSTN
        DO 400 ISUB = 31,43
        REWIND ISUB
  350 READ (ISUB,6201) VAR
      IF (EOF(ISUB)) 390,380
  380 WRITE (LUNSTN,6201) VAR
      GO TO 350
  390 CONTINUE
  400 CONTINUE
      REWIND LUNSTN
      CALL STN(LUNSTN)
      ENDFILE LUNSTN
C
C  NORMAL EXIT
      STOP
      END
      SUBROUTINE STN(ISUB)
      DIMENSION VAR(87)
      DIMENSION IVNAM(14)
      DIMENSION VAR2(87,233)
      DIMENSION IDEP(6),INDEP(8)
      INTEGER REC
      DATA IDEP/42,43,44,10,3,41/
      DATA INDEP / 20,21,39,24,25,14,18,28/
      DATA IVNAM/  10HBOD-PPD/M2,10HP-PPD/M2  ,10HNO3-PPD/M2
     $,            10HSS-TPD/M2 ,10HTUR/M2    ,10HDO-PPD/M2
     $,            10HCAT/SQ MI ,10HHOGS/SQ MI,10HLVSTK/SQMI
     $,            10HNITRO/SQMI,10HPHOS/SQ MI,10HCROP/SQ MI
     $,            10HIRRI/SQ MI,10HRAINFALL          /
      IREAD = 0
C---- READ NEXT RECORD
C
   12 READ (ISUB,201) VAR
  201 FORMAT(8F12.3)
C
C---- CHECK FO END OF FILE
C
   52 IF(EOF(ISUB))19,23
   23 IREAD = IREAD + 1
C
C---- IF NOT END OF FILE STORE DATA IN ARRAY
C
      DO 28 J=1,87
      VAR2(J,IREAD)=VAR(J)
   28 CONTINUE
      GO TO 12
C
C---- END OF FILE ENCOUNTERED, BEGIN PROCESSING
C
   19 REC=0
      IF (REC .EQ.  0 .AND. ISUB .EQ. 10) WRITE(61,2501)
      IF (REC .EQ. 0 .AND. ISUB .NE. 10) WRITE(61,250) ISUB
 2501 FORMAT(1H1,55X,15HALL SUB-BASINS )
  250 FORMAT(1H1,55X,10HSUB-BASIN ,I4)
C
C---- BEGIN DO LOOP FOR DEPENDENT VARIABLES
C
      DO 10 I=1,6
      INDX=IDEP(I)
C
C---- BEGIN DO LOOP FOR INDEPENDANT VARIABLES
C
      DO 20 J=1,8
      JNDX=INDEP(J)
      REC=REC + 5
C
C---- WRITE NEW STATION HEADINGS
C
      II=I+6
      IF (REC .GT. 50) GO TO 38
      WRITE (61,4125)
      WRITE (61,4124) IVNAM(I),IVNAM(J1),IVNAM(I),IVNAM(J1)
C
C---- BEGIN LOOP TO PROCESS ALL SUBBASIIN STATIONS
C
   38 DO 40 K=1,IREAD
C
C---- CHECK TO SEE WHETHER BOTH VARIBALES CORRELATED HAVE NON
C      ZERO VALUES FOR THIS STATION
C
   46 IF(VAR2(INDX,K).EQ.0.0.OR.VAR2(JNDX,K).EQ.0.0) GO TO 40
      IF (REC .LE. 50) GO TO 460
C
C---- WRITE NEW PAGE HEADINGS
C
      IF (ISUB .EQ. 10) WRITE(61,2501)
      IF (ISUB .NE. 10) WRITE(61,250) ISUB
      WRITE (61,4125)
      WRITE (61,4124) IVNAM(I),IVNAM(J1) ,IVNAM(I),IVNAM(J1)
 4124 FORMAT(17H STATION NUMBER  ,A10,4H BY ,A10,10X,A10,4H BY ,A10 /)
 4125 FORMAT(///,51X,24H NATURAL LOGARITHMS FOR )
      REC=0
  460 REC=REC+1
C
C---- WRITE STATION NUMBER,INDEPENDENT VARIABLE, AND DEPENDENT VARIABLE
C
      IND2=INDX + 43
      JND2=JNDX + 43
      ISTN=VAR2(1,K)
   44 WRITE (61,4126) ISTN     ,VAR2(INDX,K),VAR2(JNDX,K),
     $VAR2(IND2,K),VAR2(JND2,K)
 4126 FORMAT(5X,I8  ,F12.3,3X,F12.3,6X,F12.3,2X,F12.3)
C
C---- CLOSE  DO LOOPS (THREE OF THEM)
C
   40 CONTINUE
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
6
#
```

11. PROGRAM TO CREATE A FILE (BDS 3807) FROM TOTAL STATION

```
BARRY1,T100,CM10000.
ACCOUNT,M350415,MIDWEST,3807C.
GET,STNFIL.
RFL,50000.
FTN.
LGO.
REPLACE,TAPE53=BDS3807.
REWIND,TABLE1,TABLE2.
COPYBF,TABLE1,OUTPUT.
COPYBF,TABLE2,OUTPUT.
RFL,10000.
GET,COST(LIBRARY)
COST.
EXIT.
COPYBF,TABLE1,OUTPUT.
COPYBF,TABLE2,OUTPUT.
RFL,10000.
GET,COST(LIBRARY)
COST.
6
      PROGRAM TABLES (STNFIL,TABLE1,TABLE2,TAPE53
     $,                 TAPE10=STNFIL,TAPE51=TABLE1,TAPE52=TABLE2)
C
C  PROGRAM TO BUILD WATER QUALITY AND LAND USE TABLES ON DISK
C    FROM THE STATION FILE (REDUCED FORTRAN VERSION)
C  TABLE FILES MUST BE COPIED TO OUTPUT
C  STATION FILE RECORD
C    WORD       DESCRIPTION
C                               DATA IS INTEGER UNLESS OTHERWISE SPECIFIED
C        1  STATION NUMBER
C      2-3  STATE NAME          ALPHA
C      4-5  COUNTY NAME         ALPHA
C      6-7  STREAM NAME         ALPHA
C      8-9  LOCATION NAME       ALPHA
C       10  LATITUDE
C       11  LONGITUDE
C       12  TOTAL
C       13  TOTAL AREA
C       14  MAIN CHANNEL SLOPE            FL. PT.
C       15  RAIN INTENSITY                FL. PT.
C       16  RAIN EROSION INDEX            FL. PT.
C       17  SLOPE PCT CLASS               FL. PT.
C       18 EROSION CLASS                  FL. PT.
C       19  SOIL INFILTRATION             FL. PT.
C       20  SOIL INDEX                    FL. PT.
C    21-52  SOIL CLASS AREA TABLE (4X8) (4 CLASSES, 8 TYPES)
C    53-84  SOIL RESOURCE GROUPS  (4X8) (4 CLASSES, 8 TYPES)
C       85  DATA YEAR (1969)
C   86-175  WATER QUALITY TABLE (18X5) (18 PARAMETERS, 5 PERIODS)
C                18 PARAMETERS = SEE BELOW
C                 5 PERIODS = ANNUAL, SPRING, SUMMER, FALL, WINTER
C           WATER QUALITY PARAMETERS     FLOATING PT.
C              1  TEMPERATURE (F)
C              2  STREAMFLOW  (CFS)
C              3  TURBIDITY   (JU)
C              4  DO          (MGL)
C              5  BOD         (MGL)
C              6  PHOSPHORUS  (MGL)
C              7  TOTAL COLIFORM-1 (100ML)
C              8  TOTAL COLIFORM-2 (100ML)
```

```
C              9  FILTERED RSD (MGL)
C             10  DISSOLVED SOLIDS (TON/DAY)
C             11  NITRATE      (MGL)
C             12  HERBICIDE    (TY)
C             13  INSECTICIDE  (TY)
C             14  FUNGICIDE    (TY)
C          15-18  NOT USED
C
C      176  LAND AREA
C      177  LAND IN FARMS
C      178  OTHER LAND
C      179  TOTAL CROP AREA
C      180  CROPLAND HARVESTED
C      181  PASTURE + GRAZING
C      182  OTHER CROPLAND
C      183  IRRIGATED
C      184  OTHER FARMLAND
C      185  ROW CROPS
C      186  SMALL GRAIN
C      187  HAY
C      188  WOODLANDS
C  189-192  C-FACTORS (4) (4 CROP GROUPS)     FL. PT.
C      193  CATTLE
C      194  HOGS
C      195  SHEEP
C      196  CHICKENS
C      197  NITROGEN
C      198  PHOSPHATE
C      199  POTASH
C      200  HERBICIDE
C      201  INSECTICIDE
C      202  FUNGICIDE
C  203-207  RAINFALL (ANNUAL,SPRING,SUMMER,FALL,WINTER)
C  208-210  NOT USED
C
      DIMENSION IBUF(210)
C
      LU10  = 10
      LU51  = 51
      LU52  = 52
      LINES = 51
      NPE   = 0
      REWIND LU10
C
C  GET THE NEXT RECORD
C
  100 BUFFER IN (LU10,1) (IBUF(1),IBUF(210))
      IF (UNIT(LU10)) 130,200,120
C        * PARITY ERROR *
  120 WRITE (LU51,5101)
      WRITE (LU52,5101)
 5101 FORMAT (24H *** PARITY ERROR, NEXT LINE )
      NPE = NPE + 1
      IF (NPE.GT.10) GO TO 200
      LINES = LINES + 1
C
C  WRITE THE DATA
C
  130 IF (LINES.NE.51) GO TO 140
C        * WRITE HEADERS *
      WRITE (LU51,5102)
 5102 FORMAT (1H1,54X,23H1969 WATER QUALITY DATA //
     $,57H       STN     FLOW-CPS       TURB-JU        DO-MGL      BOD-MGL
     $,48H       TP-MGL         TCOLI1         TCOL2      RSD-MGL
     $,24H       DS-TPD      NO3-MGL       /)
      WRITE (LU52,5202)
 5202 FORMAT (1H1,56X,18H1969 LAND USE DATA //
     $,57H        STN     LAND     FARM     CROP      HARV     GRAZ   UCROP
     $,56H   OFARM   CATTL     HOGS    CHICK         N      P04     HERB
     $,16H   INSCT    RAIN     /)
      LINES = 0
C        * WRITE DATA LINE *
  140 WRITE (LU51,5103) IBUF(1), (IBUF(I),I=87,96)
 5103 FORMAT (1H ,I8,10F12.3)
      WRITE (LU52,5203) IBUF(1),IBUF(176),IBUF(177),(IBUF(I),I=179,182)
     $,    IBUF(184),(IBUF(I),I=193,194),(IBUF(I),I=196,198)
     $,    (IBUF(I),I=200,201),IBUF(203)
 5203 FORMAT (1H ,I8,14I8,F8.3)
      WRITE(53,5204) IBUF(1),(IBUF(I),I=87,96),IBUF(176),IBUF(177),
     1          (IBUF(I),I=179,184),(IBUF(I),I=193,198),IBUF(200),
     2           IBUF(201),IBUF(203)
 5204 FORMAT(I8,6F12.3/ 4F12.3/10I8/6I8,F8.3)
      LINES = LINES + 1
      GO TO 100
C
C  TABLES ARE READY TO PRINT
  200 ENDFILE LU51
      ENDFILE LU52
      REWIND LU51
      REWIND LU52
      STOP
      END
&
#
```

12. PROGRAM TO PRINT TABLES OF ALL STATION VALUES FOR VARIABLES TO BE ANALYZED

```
TABLES,T100,CM10000.
ACCOUNT,M350415,MIRWEST,3807C.
COMMON,STNFIL.
REWIND,STNFIL.
RFL,50000.
FTN.
RFL,77000.
MAP(P)
LGO.
REWIND,TAPE53.
SAVE,TAPE53=BES3807.
GET,COST(LIBRARY)
RFL,10000.
COST.
EXIT.
GET,COST(LIBRARY)
RFL,10000.
COST.
6
      PROGRAM SBASIN (TAPE31,TAPE32,TAPE33,TAPE34,TAPE35,TAPE36,TAPE37
     $,              TAPE38,TAPE39,TAPE40,TAPE41,TAPE42,TAPE43,TAPE11
     $, TAPE51,TAPE53,STNFIL,INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT
     $,TAPE10=STNFIL)
C
C  PROGRAM TO CREATE A SUB-BASIN GROUPED STATION DATA FILE
C    FROM THE STATION-NUMBER SEQUENCED STATION DATA FILE
C
      DIMENSION  IBUF(210), ISUBS(233)
      DATA  LUNCRD/60/, LUNPRT/61/, LUNBAS/10/, LUNSTN/11/
C
C  POSITION FILES
      REWIND LUNBAS
      DO 50 LUNSUB = 31,43
      REWIND LUNSUB
   50 CONTINUE
C
C  READ SUB-BASIN CODES
      READ (LUNCRD,6001) ISUBS
 6001 FORMAT ((25I3,5X))
C
C  INITIALIZATION
      IREC = 0
      WRITE(LUNPRT,6100)
 6100 FORMAT (1H1)
C
C  READ NEXT BASIN RECORD
  100 IREC = IREC + 1
      BUFFER IN (LUNBAS,1) (IBUF(1),IBUF(210))
      IF (UNIT(LUNBAS)) 120,200,110
C         *READ PARITY*
C 110 STOP 1002
  110 CONTINUE
C
C  DETERMINE SUB-BASIN CODE
  120 ISUB = ISUBS(IREC)
      WRITE(LUNPRT,6101) IREC,IBUF(1),ISUB
      WRITE(LUNPRT,9302) IBUF(15)
 9302 FORMAT (I8)
 6101 FORMAT ( 8H RECORD ,I5, 9H STATION ,I10,11H SUB-BASIN ,I3 )
      IF (ISUB.LE.0) GO TO 100
```

```
C
C  WRITE RECORD TO PROPER SUB-BASIN FILE
      BUFFER OUT (ISUB,1) (IBUF(1),IBUF(210))
      IF (UNIT(ISUB)) 100,160,170
C         *WRITE EOF*
  160 STOP 1101
C         *WRITE PARITY*
  170 STOP 1102
C
C
C  PRINT TABLES FOR EACH SUB-BASIN
C
  200 DO 300 ISUB = 31,43
      REWIND ISUB
      CALL TABLES(ISUB)
  200 CONTINUE
C
C  RECOMBINE SUB-BASIN FILES INTO ONE STATION FILE
      DO 400 ISUB = 41,43
      REWIND ISUB
  350 BUFFER IN (ISUB,1) (IBUF(1),IBUF(210))
      IF (UNIT(ISUB)) 370,400,360
C         *READ PARITY*
  360 STOP 2102
      BUFFER OUT(LUNSTN,1)(IBUF(1),IBUF(210))
      IF (UNIT(ISUB))350,400,360
  400 CONTINUE
      REWIND LUNSTN
      REWIND LUNSTN
      CALL TABLES(LUNSTN)
      ENDFILE LUNSTN
C
C  NORMAL EXIT
      STOP
      END
      SUBROUTINE TABLES (ISUB)
C
C  PROGRAM TO BUILD WATER QUALITY AND LAND USE TABLES ON DISK
C    FROM THE STATION FILE (REDUCED FORTRAN VERSION)
C      AND THEN PRINT THEM OUT
C
C  STATION FILE RECORD
C    WORD       DESCRIPTION
C
C                             DATA IS INTEGER (I8) UNLESS OTHERWISE SPECIFIED
C       1   STATION NUMBER
C     2-3   STATE NAME           ALPHA (A10,A6)
C     4-5   COUNTY NAME          ALPHA
C     6-7   STREAM NAME          ALPHA
C     8-9   LOCATION NAME        ALPHA
C      10   LATITUDE
C      11   LONGITUDE
C      12   TOTAL
C      13   TOTAL AREA
C      14   MAIN CHANNEL SLOPE              FL. PT. (F8.3)
C      15   RAIN INTENSITY                  FL. PT.
C      16   RAIN EROSION INDEX              FL. PT.
C      17   SLOPE PCT CLASS                 FL. PT.
C      18 EROSION CLASS                     FL. PT.
C      19   SOIL INFILTRATION               FL. PT.
C      20   SOIL INDEX                      FL. PT.
C   21-52   SOIL CLASS AREA TABLE (4X8) (4 CLASSES, 8 TYPES)
C   53-84   SOIL RESOURCE GROUPS  (4X8) (4 CLASSES, 8 TYPES)
C      85   DATA YEAR (1969)
C  86-175   WATER QUALITY TABLE (18X5) (18 PARAMETERS, 5 PERIODS)
C                18 PARAMETERS = SEE BELOW
C                 5 PERIODS = ANNUAL, SPRING, SUMMER, FALL, WINTER
```

```
C          WATER QUALITY PARAMETERS     FLOATING PT. (F12.3)
C              1  TEMPERATURE (F)
C              2  STREAMFLOW  (CFS)
C              3  TURBIDITY   (JU)
C              4  DO          (MGL)
C              5  BOD         (MGL)
C              6  PHOSPHORUS  (MGL)
C              7  TOTAL COLIFORM-1 (100ML)
C              8  TOTAL COLIFORM-2 (100ML)
C              9  FILTERED BSD (MGL)
C             10  DISSOLVED SOLIDS (TON/DAY)
C             11  NITRATE     (MGL)
C             12  HERBICIDE   (TY)
C             13  INSECTICIDE (TY)
C             14  FUNGICIDE   (TY)
C          15-18  NOT USED
C
C      176  LAND AREA
C      177  LAND IN FARMS
C      178  OTHER LAND
C      179  TOTAL CROP AREA
C      180  CROPLAND HARVESTED
C      181  PASTURE + GRAZING
C      182  OTHER CROPLAND
C      183  IRRIGATED
C      184  OTHER FARMLAND
C      185  ROW CROPS
C      186  SMALL GRAIN
C      187  HAY
C      188  WOODLANDS
C  189-192  C-FACTORS (4) (4 CROP GROUPS)    FL. PT. (F8.3)
C      193  CATTLE
C      194  HOGS
C      195  SHEEP
C      196  CHICKENS
C      197  NITROGEN
C      198  PHOSPHATE
C      199  POTASH
C      200  HERBICIDE
C      201  INSECTICIDE
C      202  FUNGICIDE
C  203-207  RAINFALL (ANNUAL,SPRING,SUMMER,FALL,WINTER) FL.PT. (F8.3)
C  208-210  NOT USED
C
      DIMENSION BUF(210)
      DIMENSION IBUF(210)
      DIMENSION TEMP1(8),TEMP2(9)
      EQUIVALENCE (IBUF(1),BUF(1))
      EQUIVALENCE (TEMP1(1),IBUF(89))
      EQUIVALENCE (TEMP2(1),IBUF(193))
      DATA  LU51/51/, LU52/52/, LUNPRT/61/
C
      LU10  = 150B
      NRECS = 0
      LINES = 51
      NPF   = 0
      REWIND LU10
      REWIND LU51
      REWIND LU52
C
C  GET THE NEXT RECORD
C
  100 BUFFER IN (LU10,1) (IBUF(1),IBUF(210))
      IF (UNIT(LU10)) 130,200,120
C       * PARITY ERROR *
  120 WRITE (LU51,5101)
```

```
      WRITE (LU52,5101)
 5101 FORMAT (28H *** PARITY ERROR, NEXT LINE )
      NPE = NPE + 1
      IF (NPE.GT.10) GO TO 200
      LINES = LINES + 1
C
C  WRITE THE DATA
C
  130 IF (LINES.NE.51) GO TO 140
C        * WRITE HEADERS *
      IF (LU10 .EQ. 11) GO TO 132
      WRITE (LU51,5102) ISUB
 5102 FORMAT (1H1,46X,37H1969 WATER QUALITY DATA FOR SUB-BASIN ,I3 //
     $,57H        STN     FLOW-CFS      TURB-JU       DO-PPD      BOD-PPD
     $,48H        TP-PPD         TCOL1          TCOL2      RSD-PPD
     $,24H        DS-TPD      NO3-PPD       /)
      WRITE (LU52,5202) ISUB
 5202 FORMAT (1H1,48X,32H1969 LAND USE DATA FOR SUB-BASIN ,I3 //
     $,57H        STN     LAND      FARM      CROP      HARV      GRAZ    OCROP
     $,56H    OFARM    CATTL      HOGS    CHICK          N       PO4      HERB
     $,16H    INSCT     RAIN     )
      GO TO 141
  132 WRITE (LU51,5502)
      WRITE (LU52,5602)
 5502 FORMAT (1H1,46X,38H1969 WATER QUALITY DATA FOR ALL BASINS,//
     $,57H        STN     FLOW-CFS      TURB-JU       DO-PPD      BOD-PPD
     $,48H        TP-PPD         TCOL1          TCOL2      RSD-PPD
     $,24H        DS-TPD      NO3-PPD       /)
 5602 FORMAT (1H1,48X,33H1969 LAND USE DATA FOR ALL BASINS,//
     $,57H        STN     LAND      FARM      CROP      HARV      GRAZ    OCROP
     $,56H    OFARM    CATTL      HOGS    CHICK          N       PO4      HERB
     $,16H    INSCT     RAIN     )
  141 WRITE (LU52,5204)
 5204 FORMAT(68X,45H-----     ----    -----      ----     ----    ----
     $,16H   -----          )
      WRITE (LU52,5205)
 5205 FORMAT(68X,45HACRE       ACRE    ACRE       ACRE     ACRE    ACRE
     $,8H   ACRE /)
      LINES = 0
C          *****MAKE CONVERSIONS TO PROPER UNITS******
C
C---- CONVERT TO POUNDS PER DAY
C
  140 TEMP1(1) = 5.39 * BUF(87) * BUF(89)
      TEMP1(2) = 5.39 * BUF(87) * BUF(90)
      TEMP1(3) = 5.39 * BUF(87) * BUF(91)
      TEMP1(6) = 5.39 * BUF(87) * BUF(94)
      TEMP1(8) = 5.39 * BUF(87) * BUF(96)
C
C---- CONVERT TO PER ACRE TOTALS
C
      DO 125 I=1,9
      INDX=I + 192
      TEMP2(I)= FLOAT(IBUF(INDX)) / FLOAT(IBUF(176))
  125 CONTINUE
C        * WRITE DATA LINE *
      WRITE (LU51,5103) IBUF(1), (IBUF(I),I=87,96)
 5103 FORMAT (1H ,I8,10F12.3)
      WRITE (LU52,5203) IBUF(1),IBUF(176),IBUF(177),(IBUF(I),I=179,182)
     $,   IBUF(184),(IBUF(I),I=193,194),(IBUF(I),I=196,198)
     $,   (IBUF(I),I=200,201),IBUF(203)
 5203 FORMAT (1H ,8I8,8F8.3)
      LINES = LINES + 1
      NRECS = NRECS + 1
      GO TO 100
C
```

```
C  TABLES ARE READY TO PRINT
  200 ENDFILE LU51
      ENDFILE LU52
      REWIND LU51
      REWIND LU52
C
C  PRINT TABLES
  250 READ (LU51,6101)
 6101 FORMAT (132H
     $
     $
      IF (EOF(LU51)) 300,260
  260 WRITE (LUNPRT,6101)
      GO TO 250
  300 READ (LU52,6101)
      IF (EOF(LU52)) 400,310
  310 WRITE (LUNPRT,6101)
      GO TO 300
C
C  PRINT RECORD COUNT
  400 WRITE (LUNPRT,6102) NRECS
 6102 FORMAT (1H1,I5,13H RECORDS READ )
C
C  NORMAL EXIT
      RETURN
      END
SAVE,TAPE11=STNFIL.
C  WRITE RECORD TO NEW BASIN FILE
  370 BUFFER OUT (LUNSTN,1) (IBUF(1),IBUF(210))
      IF (UNIT(LUNSTN)) 350,380,390
C         *WRITE EOF*
  380 STOP 2001
C         *WRITE PARITY*
  390 STOP 2002
6
 41 39 35 31 31 41 41 41 41 40 40 40 40 43 43 43 43 43 42 42 43 43 43 43 43
 43 43 43 43 43 43 43 43 43 43 43 43 43 43 42 42 42 42 42 42 42 42 42 39 39
 39 39 38 38 38 38 38 38 38 38 38 37 37 37 37 37 37 37 37 37 36 36 36 36 36
 36 36 36 36 36 36 36 36 36 36 36 36 36 35 35 35 35 35 35 35 35 34 34 34 34
 34 34 34 34 33 33 34 34 34 34 34 34 34 33 33 33 33 34 34 34 34 33 33 33 34
 34 34 34 34 34 34 34 33 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35
 35 35 35 35 35 35 31 31 31 31 31 31 31 31 31 33 33 33 33 33 32 32 32 32 32
 32 32 33 33 33 33 33 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32
 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 31 31 31 31 31 31 31 31 31
 31 31 31 31 31 31 31 31
6
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